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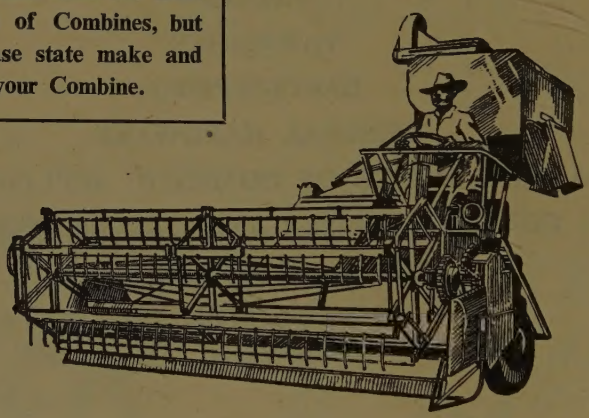

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THE

EAST AFRICAN AGRICULTURAL JOURNAL

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THE SCIENTIFIC WORK OF E.A.A.F.R.O.

The Annual Report of the East African Agriculture and Forestry Research Organization for 1951, which was published recently, describes in some detail the wide range of research which is being undertaken by the Organization. A brief summary may interest those who wish to know what is going on rather than how it is being done.

As the new headquarters at Muguga, some 17 miles north-west of Nairobi, were opened only in May, 1951, the research staff is not yet at full strength, but work is proceeding on many lines, both in the main laboratories and at the outstations. The plant pathologists are continuing at Muguga much of the work on virus diseases of plants that was started at Amani. In particular they are studying the manner in which aphids transmit the virus of groundnut rosette, a disease that is important throughout Africa. A new line of work deals with the virus diseases of sweet potato, concerning which little is known beyond the fact that they occur in all East African territories and have caused the crop to be abandoned in parts of the Belgian Congo. Amani, however, remains the site for breeding and testing Cassavas; good progress is recorded towards producing types highly resistant to the two virus diseases, mosaic and brown streak. Already the introduction of Amani varieties into Uganda has raised the Cassava yield sevenfold in one large area. One research officer has been working on a station of the Kenya Forestry Department in a search for means to control canker disease that is doing much damage to cypress plantations in many parts of East Africa.

Entomological research is represented by two workers on widely different lines: one has been transferred from the Kenya Forest Department and has begun a survey of the forest insects of East Africa. With the inadequate staff available, this can only be done if both officials and settlers will co-operate by sending information to the Forest Entomologist, E.A.A.F.R.O., P.O. Box 21, Kikuyu, Kenya. The other entomologist has been posted to the research station of the Empire Cotton Growing Corporation at Namulonge, in Uganda, to investigate the methods of application of insecticides and their effectiveness on many food crops in addition to economic crops such as cotton. In the biological field, a Colonial Development and Welfare Scheme on termite research has been attached to E.A.A.F.R.O., and two research officers are stationed at Muguga, while one is centered at Amani. Their task is primarily that of collecting and identifying the termites of East Africa (of which there are more than a hundred species), but this fundamental study frequently yields results of direct practical value, as the habits and habitat of the economically important species which attack living crops and timber are worked out.

Starting with native food crops, the section on plant breeding is now in the preliminary stages of its work. During the past four years, the members of this section carried out a comprehensive programme of fertilizer experiments in native areas, solely on food crops, and their results are now being correlated with similar investigations conducted by the three Departments of Agriculture. Physiological studies on the maize plant were complementary to these field fertilizer trials, and the controlled experiments on the uptake of phosphorus and nitrogen, and the relation between these two elements, explained many of the erratic results which are so frequently obtained with applications of phosphate.

Recently, a new line of study has been started on plant physiology, on the Pyrethrum Bud Disease, which is affecting the yields of pyrethrum in East Africa. The cause of the disease is known to be the fungus *Ramularia bellunensis,* but the incidence of the disease may be related both to the microclimate in the pyrethrum clump and the nutritional status of the plant. Pathologists are collaborating in this work, which is being carried out jointly with the Kenya Department of Agriculture and is partly financed by the Pyrethrum Board of Kenya.

The importance of soil and ecological surveys is fully appreciated in the less developed parts of the Commonwealth, and conjoint work in these fields has now been centred at Muguga. A Colonial Development and Welfare Scheme for training specialist officers in ecological methods is now in its final stage of preparation, and surveys carried out by the trainees will be closely linked with

the soil survey section, which is now collecting all available information on the soil types of East Africa. Work on these two lines of survey is slow under the best of circumstances, but it is unfortunate that financial difficulties have cut the facilities to a level at which progress will be laboriously slow.

For some years past, laboratory studies of the phosphate content of soils and its relation to fertilizer response have been carried out in co-operation with the section on field fertilizer experiments. Some progress has been made in finding out why applications of phosphate to a soil which is chemically deficient in that element may or may not have a beneficial effect. It is well known that, up to now, chemical analysis cannot always tell whether a phosphate-deficient soil will benefit from applications of phosphate fertilizers, and in this, tropical soils, particularly those with high clay content, were even more difficult than those of temperate regions. It appears, however, that the proportion of other plant foods on the clay particle, such as calcium, magnesium, sodium and potassium, influences the magnitude of phosphate response. When the clay particle is nearly saturated with these bases, the soil phosphate seems to remain on the surface of the complex, and thus is available to plants, so that responses to phosphatic fertilizers are not usually obtained. When the proportion of calcium and other bases is low the soil phosphate appears to be absorbed into the clay particle and held there so firmly that it is not available to plants and phosphate fertilizers are then needed. In spite of this progress, work on the difficult problem of soil phosphate is only in its infancy, and much remains to be done before the results can be applied in farming practice without fail.

Another investigation on soil fertility is being carried out in collaboration with the termite research unit. It has been assumed that termites have a wide influence on soil fertility, in that they collect organic debris from the surrounding soil, carry it to their nests, and concentrate much of the fertility of the area in their mounds. Observations have appeared in scientific journals suggesting that termites accumulated lime in their nests, sometimes to the point of producing crystalline calcium carbonate. The importance of collaboration in this work was apparent when chemical analysis of living termite mounds and their surrounding soil showed no accumulation of fertility within the mound. A biological observation is that the species of termite concerned literally wastes nothing, in that every particle of organic matter which enters the mound is utilized to build the bodies of termites, and even the dead termite is galvanized into new activity by absorption into his brother's body fluids. It is too early to draw conclusions from the preliminary investigations, since other factors such as drainage are involved in the relationship between termites and soil fertility, but at least we are beginning to see faint glimmerings of light in the problem.

The forestry section is now collating silvicultural problems in East Africa, and plans have been prepared for making the best use of the limited staff which is available in the three territories for forestry research. Forest nursery technique is a problem of great economic importance in plantation forestry, and the Horticulturist of E.A.A.F.R.O. is now fully occupied in the forestry section. A bureau has also been started, in which at present only silvicultural information is collected, but its scope may be widened when facilities permit. An outstanding feaure of this inter-territorial forestry section is the way in which valuable information is being extracted from departmental files and from the old German records in the E.A.A.F.R.O. library. The saving of time and money resulting from the activities of this bureau cannot be overestimated, and it is obvious that it is fulfilling a long-felt want.

Conservation of the water resources of the East African territories is of vital importance in their economy, and the Soil Physics section of E.A.A.F.R.O. is working with other specialist departments to find out what happens to rain after it reaches the ground. The management of catchment areas plays a major role in the conservation of water supplies, and it is fortunate that an American scientist with wide experience in forest hydrology has chosen East Africa as his field for extended study and he is now attached to E.A.A.F.R.O. for a period of 12 to 18 months. His experience will be of the greatest value in the field of soil physics because the uncertainty of rainfall in many parts of East Africa makes soil moisture the limiting factor in crop production, and an elucidation of the movement of rain water in and under the soil is of direct economic interest.

The Clove Research Scheme, which was set up primarily to study the "Sudden-death" disease of cloves in Zanzibar, is under the

general scientific supervision of the Director of E.A.A.F.R.O. Although the primary cause of "Sudden-death" still requires final proof, the organism responsible for an associated disease called "die-back" has been identified as a fungus, and control measures have been worked out and successfully tried on a plantation scale. While working on the entomological side of the "Sudden-death" problem, one of the scientists in the team found that a disease of coconuts which had been known for over 30 years as "Gumming Disease" is caused by a coreid bug, a species of *Theraptus*. It is naturally controlled by a species of ant which inhabits both clove and coconut trees, but this ant is in turn preyed on by other species of ants. Where the balance of nature is against the former, *Theraptus* runs riot and may reduce the yield of nuts to an insignificant amount. If the balance can be adjusted to favour the ant which feeds on *Theraptus*, or alternatively, the bug can be controlled by insecticides, the coconut industry of Zanzibar and the coastal districts of Kenya and Tanganyika will benefit very markedly.

In addition to these numerous lines of scientific work, there are others which are not so spectacular. The analysts and the statisticians cannot catch the public eye, and other work is in progress which, it is hoped, will produce results which will eventually influence farming practice.

D.W.D.

A DIRECTORY OF SCIENTIFIC LIBRARIES

The Scientific Council for Africa South of the Sahara (C.S.A.) among its activities on behalf of African science, is paying special attention to library and information services. We recognize three stages in the collection and distribution of information about African scientific libraries: the first is the compilation of a directory covering all or as many as possible of these libraries; the second is the preparation of lists of periodical literature held in these libraries (for East Africa such a list was published by the East Africa High Commission in June, 1949, and can be obtained from Box 601, Nairobi); the third stage should be the compilation of detailed library catalogues. At present C.S.A. is engaged only on the first stage.

In order to obtain requisite information for inclusion in a scientific library directory, a simple questionnaire has been issued to several hundred libraries in Africa south of the Sahara, including a good number in the East African territories. The Union of South Africa has not been included in this inquiry because for that country there is already a complete directory of scientific, technical and medical libraries.

It is possible that some libraries in the East African region have been overlooked. C.S.A. would be glad to hear from any scientific or technical library which may not have received or replied to the questionnaire, and also from anyone who would like further information about this work.

E. B. WORTHINGTON,
Secretary-General, C.S.A.
2nd April, 1952. *P.O. Box* 21, *Kikuyu, Kenya.*

CALCULATIONS OF THE WETNESS OF AIR

By J. Glover, E.A.A.F.R.O., Kenya

(*Received for publication on 2nd May,* 1952)

The importance of the water content of the air to the survival and growth of all living things needs no stressing. Not only do major changes in the evaporation of water and its condensation as rain affect everyone to some degree, but even the less obvious smaller changes play an important role in our lives.

Most farmers are particularly concerned with the wetness of air in drying crops, for such diverse items as sisal, cotton, coffee, pyrethrum and maize must be dried if they are to be safely stored. The rate of drying is particularly important as it is obviously uneconomic to have too large or too small drying facilities. Further, if labour or machinery is used to spread the material for drying in the open air, it may be found uneconomic to use them during certain hours of the day if drying proceeds slowly. In other cases, drying may be so rapid and thorough that baling or storing troubles may be caused later. For example, cotton bales stored in a coast port burst their bonds during wet weather because they had reabsorbed water from the air during storage. The trouble was cured by maintaining the air in the baling shed at a suitable humidity.

Practical problems such as this can be solved by the man on the spot if he understands the use of instruments in measuring the drying power of the air. In an endeavour to help those who wish to judge for themselves the economic basis of drying, the following notes on the measurement of the drying power of the air have been prepared. The instruments used and their approximate cost (1951) are also described in some detail.

Instruments

There are many methods of measuring the wetness of air, but the two most common instruments in practical everyday use are psychrometers and hair hygrometers. The first are the most accurate, and all the properties of wet air can be calculated from the data they provide; the latter only show relative humidity, and if the drying power of the air is to be calculated from them a thermometer must also be used to measure air temperatures at the same time.

It should perhaps be emphasized at this point that the calculations which are shown later in the paper can only be considered as approximately accurate at elevated temperatures. The formulæ given can be used at air temperatures up to the boiling point of water without serious error, provided that the air velocity over the thermometer reaches at least seven miles per hour.

Psychrometers

In these instruments the air to be tested passes over two carefully matched and screened thermometers; one thermometer bulb is dry, the other is kept moist by a muslin wick which is wetted before a reading is taken. The dry bulb shows true air temperature, and the wet bulb shows the lower temperature due to the cooling effect of the loss of water to the air which passes over it; the drier the air, the greater the loss and the lower the wet bulb temperature. The most accurate results are attained when air is drawn over the bulbs fairly rapidly. In the Assmann psychrometer (*Fig.* 1) a clockwork fan in the head of the instrument performs this function. The whirling of a sling psychrometer (*Fig.* 2) does the same thing. The difference in temperature is therefore a measure of the wetness of the air, and this is used in calculations which will be shown later. In practice a set of tables is obtained for each type of psychrometer and it is generally

Fig. 1. An Assmann Psychrometer.

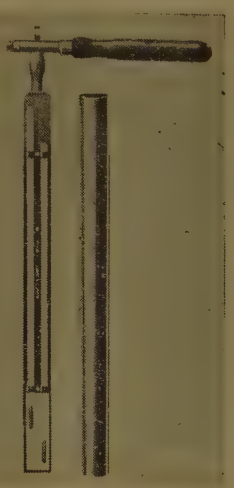

Fig. 2.—A Sling Psychrometer.

easy to look up the required information in them. Their cost is about £10 and upwards, depending on the type. Recording instruments may cost £50 or more.

Hair Hygrometers

These more common instruments depend on the contraction and expansion of a bundle of hair with changes in the saturation of air by water vapour. The movement of the hairs is used to operate a pointer which traverses a scale showing the percentage saturation of the air by water vapour, i.e. the relative humidity. They are generally exposed in slotted screens which protect them from direct heat, yet which provide adequate ventilation. Frequently a bi-metallic strip thermometer is included in the same case and simultaneous temperature measurements are made. The pointers then generally carry pens which record the changing values on a clockwork-driven chart. It is then called a Thermo-hygrograph (*Fig.* 3). If non-continuous readings are required, a separate good quality mercury thermometer exposed near the hygrometer is of course as satisfactory as the bi-metallic strip thermometer, but its changes are more difficult to record. The bulb should be shielded from direct sunlight or other source of heat by bright aluminium or tinfoil and a current of air should pass over it.

The water content of the air at different temperatures and humidity readings can be looked up in a book of tables, and the drying power of the air can then be easily calculated. The results of these calculations are likely to be inaccurate unless the hair hygrometer is frequently recalibrated. Simple hair hygrometers of different shapes for different purposes cost about £5 to £10, and a good thermometer about £1 to £3. Thermohygrographs are more expensive.

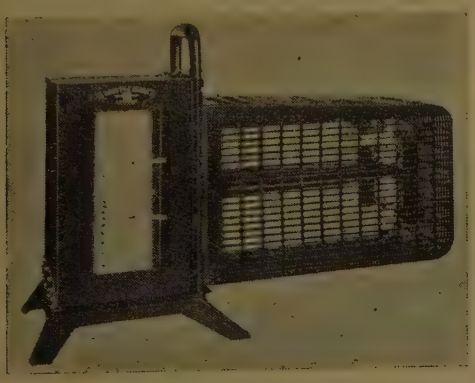

Fig. 3.—A Thermohygrograph

As with psychrometers, the best results are obtained when a current of air passes over the thermometer and hair. Hair hygrometers need frequent recalibration, particularly if they have been strained by extremely dry conditions. Their main purpose is to provide a rough picture of changes in humidity, rather than a precise measurement.

Measurements

The terms most commonly used to describe in different ways the wetness of air are *relative humidity*, *absolute humidity* or *saturation deficit*. These terms are defined as follows:—

Absolute humidity is the actual moisture content of the air, i.e. weight of water vapour per unit volume of air. It is generally expressed as grams of water per cubic metre of air.

Relative humidity is the percentage amount of water held in the air at a given temperature compared with the amount required to saturate the air at that temperature, i.e. the actual amount in the air at a given temperature divided by the amount required for saturation at the same temperature, multiplied by 100.

Saturation deficit is the difference between the amount of water vapour in the air and the amount which is required for saturation at the given temperature. It is generally expressed as a difference in vapour pressure (millimetres mercury, or millibars) but may also be expressed as grams of water vapour per cubic metre of air.

It can be seen that *absolute humidity* tells how much water is contained in a unit volume of air, *relative humidity* tells how much the air is saturated, and *saturation deficit* tells how much water the air can take up. The first, though a fundamental measurement, is rarely used except in specialized cases, but the latter two, relative humidity and saturation deficit, are in frequent use. In order to show how they are calculated and their relative value, the following notes have been prepared.

At any given temperature there is a limit to the amount of water which can be taken up by the air; that is, the air can hold no more water than the amount required to saturate it. Since water vapour is a gas and, like water, has weight, it exerts a pressure, so we can speak of water vapour pressure as well as air pressure. The water vapour in saturated air at a given temperature exerts a pressure known as the saturation vapour pressure. If the water content of the air is less than that required for

saturation, then the partial water content exerts a partial vapour pressure. The partial vapour pressure is therefore a measure of the water content of the air at any given temperature. If we know it we can calculate the actual moisture content of the air, and if we also know the saturation vapour pressure we can also calculate *relative humidity* and *saturation deficit*. Obviously the partial vapour pressure is markedly affected by temperature and barometric pressure, so these must be included in the calculations.

The partial vapour pressure of water in air, "e" in millimetres of mercury, was shown to be connected with the saturation vapour pressure of the air at the temperature of the *wet* bulb by the following formula for Assmann psychrometers:—

$$(A)\quad e = E_w - \tfrac{1}{2}\,(t_d - t_w)\frac{b}{755}$$

Where E_w is the saturation vapour pressure at the wet bulb temperature, t_d is the temperature of the dry bulb in degrees Centigrade, t_w is the temperature of the wet bulb in degrees Centigrade, and b is the barometric pressure in millimetres of mercury. The actual amount of water held by the air which produces this partial vapour pressure (e) can then be calculated from the following formula—

$$(B)\quad d = 216.7\frac{e}{T_A}$$

Where "d" is the number of grams of water held in every cubic metre of air, "e" is the partial vapour pressure in *millibars* (i.e. vapour pressure in mms. × 1.3) and "T_A is the absolute temperature ($273 + t_d$°C.) of the dry bulb.

For example, if we wish to know the actual amount of water held by air at a barometric pressure of 755 mm. of mercury whose dry and wet bulb temperatures are 20° C. and 15° C. respectively, the procedure is as follows—

Find the partial vapour pressure "e" by first looking up the saturation vapour pressure at the *wet bulb* temperature (E_w) in a table of such pressures. The value for E_w at 15° C. is found to be 12.79 mm. of mercury. Substitute this and the temperature and pressure values in the formula given above (A). This in numerical values is now—

$$e = 12.79 - \tfrac{1}{2}\,(20 - 15)\,\frac{755}{755}\text{ mm. of mercury} = 10.29\text{ mm. of mercury.}$$

Knowing "e" to be 10.29 we can substitute this value in formula (B), so that we now have—

$$d = 216.7 \times \frac{10.29 \times 1.3}{273 + 20} = 10.15\text{ grams/cubic metre.}$$

Having calculated the amount of water which the air contains, it is now possible to calculate the amount of water the air can take up (drying power or saturation deficit). The vapour pressure of the total amount of water which could be held at the dry bulb temperature is 17.54 mm. of mercury (the saturation vapour pressure at the temperature of the *dry* bulb). The vapour pressure which was actually present under the above conditions was 10.29 mm. of mercury, so 17.54 − 10.29 or 7.25 mm. of mercury represents the vapour pressure still to be satisfied. This represents a drying power of $216.7 \times \frac{7.25 \times 1.3}{293} = 7.15$ grams/cubic metre, so each cubic metre of air under the above conditions could take up 7.15 grams of water before reaching the point of saturation.

In practice the calculations can be made quickly by reference to standard tables of vapour pressures.

Relative humidity is the percentage saturation of the air. Air under the conditions described above would have its relative humidity calculated as follows—

$$(C)\quad \%\ \text{R.H.} = \frac{e}{E_d} \times 100 = \frac{10.29}{17.54} = 59\%.$$

Where "e" is as before and E_d is the saturation vapour pressure at *dry bulb* temperature.

Since relative humidity is only a measure of the percentage saturation and since it is dependent on temperature, the same percentage saturation at different temperatures does not imply that the air possesses the same drying power at different temperatures.

The following Table (I) illustrates the differences in quality of the different measurements.

TABLE I

Temperature °C.				
Dry bulb t d	Wet bulb t w	% R.H.	Sat. deficit in mm. mercury	Sat. deficit in gm.
20·0	15	59	7·25	7·15
14·1	10	59	4·87	4·90
8·4	5	59	3·47	3·56

Obviously the air at 20° C. can take up twice the amount of water that air at 8.4° C. can take up, yet both have the same relative humidity.

At this point it can be seen that knowledge of dry bulb temperature and relative humidity can be used for the calculation of the amount of water vapour in the air. Thus at a relative humidity of 59 per cent, at 20° C. we know saturated air has a vapour pressure of 17.54 mm. Hg. so substituting in (C) we have $59 = \frac{e}{17.54} \times 100$,

i.e. "e" = 10.35 mm. Hg.

and from this the absolute humidity or saturation deficit may be calculated.

The implications of the two methods of measurements should now be clear; if we want to describe the drying power of the air then the *saturation deficit* must be measured; if the percentage saturation of the air is all that is required, then *relative humidity* expresses it clearly and concisely, but it should never be forgotten that it is, as its title describes, only a relative measure.

CORRECTIONS FOR PRESSURE

The standard tables of relative humidity or vapour pressure, which simplify calculations, are based on standard barometric pressures at sea level. They require correction if used at any other pressure.

At any one site in East Africa, variations in pressure throughout the day and from day to day are negligible so, even if standard data are used in the calculations, measurements of relative humidity at that site can be compared one with the other for, unless at sea level, they are equally in error. On the other hand, the comparison of humidities at different altitudes must be examined with care for unless they are corrected for the difference in pressure they may be misleading.

The following Table (II) shows how the difference in pressure at different altitudes greatly exceeds the small diurnal variation—

TABLE II

(From the Summary of Meteorological Observations for 1950, E.A. Met. Dept.)

	Nairobi (Airfield)	Mombasa (Port Reitz)
Altitude in feet	5,360	200
Mean Yearly Pressure (mb) at 8.30 a.m.	840	1,008
Mean Yearly Pressure (mb) at 2.30 p.m.	837	1,005

The general formula for corrections for pressure for the Assmann psychrometer is—

$$D \text{ "e"} = \tfrac{1}{2} (t_d - t_w) \frac{755-b}{755}$$

where D "e" is the correction for the vapour pressure in millimetres of mercury and "b" is the barometric pressure. It can be seen that if the barometric pressure "b" is less than 755 mm. of mercury (or 1,007 mb.) the correction D "e" is positive and must be added to the reading of the partial vapour pressure "e" and vice versa.

ACKNOWLEDGMENT

The text photographs were kindly supplied by Messrs. Negretti and Zambra.

REFERENCE

(1) Aspirations—Psychrometer—Tafeln. Preussischen Meteorological Institut Braunschweig, 1930.

WILT OR PANAMA DISEASE OF BANANA

By G. B. Wallace, Plant Pathologist, Department of Agriculture, Tanganyika

(*Received for publication on 18th February,* 1952)

In Tanganyika, wilt or Panama disease of banana was found in native plots on the lower slopes of Kilimanjaro and on the plain below in August, 1951. The plan in Figure 1 shows the positions of the known affected sites in February, 1952. The elevations of the infected areas are from 2,260 ft. to 3,800 ft. above sea level. The disease was first observed as something unusual by an African Instructor of the Department of Agriculture, who reported it to the Agricultural Officer, Moshi, and to the laboratory. The similarity of the new disease to wilt was at once evident. A fungus was found to be invariably present in diseased tissue and was suspected to be *Fusarium oxysporum* forma *cubense,* the known cause of wilt; this identification was confirmed by the Director of the Commonwealth Mycological Institute, Kew, to whom cultures were sent.

Banana wilt is one of the most destructive and infectious diseases of cultivated plants. In parts of the West Indies, for example, many thousands of acres have been put out of cultivation. The fungus is known to persist in the soil for an indefinite number of years. One can only endeavour to confine it and restrict the losses it can cause. In Africa, banana wilt is known in Sierra Leone, the Gold Coast, Cameroons, French Guinea, the Canary Islands and Mauritius. It is widely distributed in most banana-growing countries, e.g. in India and the Far East, Queensland and New South Wales, Central America, West Indies, Mexico and Florida.

The origin of the disease in Tanganyika cannot be known with certainty; there are no imports of banana from outside East Africa. The most plausible suggestion is that, in the course of troop movements in recent years between Mauritius and the now endemic district of Moshi, infected soil has been introduced on the roots of plants such as cassava or sweet potato. One local African banana grower reported that he had observed the disease in his plot in 1950, but had confused it with Armillaria root rot. The present distribution and intensity of the disease seem to indicate that it entered the country in 1950, or at least that it reached banana groves in that year. According to native statements the disease did not become serious until after the April–May rains of 1951. The extent of the infected areas was immediately investigated, and a regular inspection of banana fields is being maintained in the Moshi and neighbouring districts.

There is considerable danger of the disease spreading to other districts by roads, railways or rivers, and it seems inevitable that it will become more widespread. The seriousness of this threat is realized and precautions are being taken.

Uses of the Banana Plant

It would be opportune to recall here the economic importance of the banana on Kilimanjaro. It is the most important food crop on the mountain, yielding, according to the Agricultural Officer, Moshi, about 100,000 tons of fruit per annum on some 65,000 acres. The maize crop has now reached 50,000 tons on about 85,000 acres. Other crops are beans and peas, finger millet (for beer), Irish potato, tanier, yam, sweet potato, pigeon pea, cassava and vegetables. In addition to its use as food —raw, roasted and boiled—the banana is the chief source of native beer. Banana figs are not prepared and banana flour is seldom seen. Leaves and stems are fed to cattle. Dried-out separated leaf-bases which form the stem are a source of thatch. Leaves and the dried fibrous leaf-bases serve for wrapping and tying loads. Banana plants are one source of shade for coffee, and the leaves are used for mulch. Plants growing on the steeper slopes are, when fully established, a useful anti-erosion crop. Fresh leaf-bases are used for diverting water in irrigation.

While the names of banana varieties have very local application, some names used in the Machame area of Kilimanjaro are referred to below. On this mountain there are four sweet varieties eaten raw: three *Kisukari* varieties (*kifii* kyaasha* and *jivu-jivu,* the latter being grown only near the larger rivers on the plain) and the variety *Ifwanaiya.* For roasting and boiling the three "Nshare" varieties *Nlelembo, Nshonowa* and *Kinguruwe** (the *Kimalindi* of other districts) are the most common; a fourth,

* *Kisukari kifii* and *Kinguruwe* are tentatively identified by Baker and Simmonds(1) as Guindy and Cavendish (Dwarf Chinese).

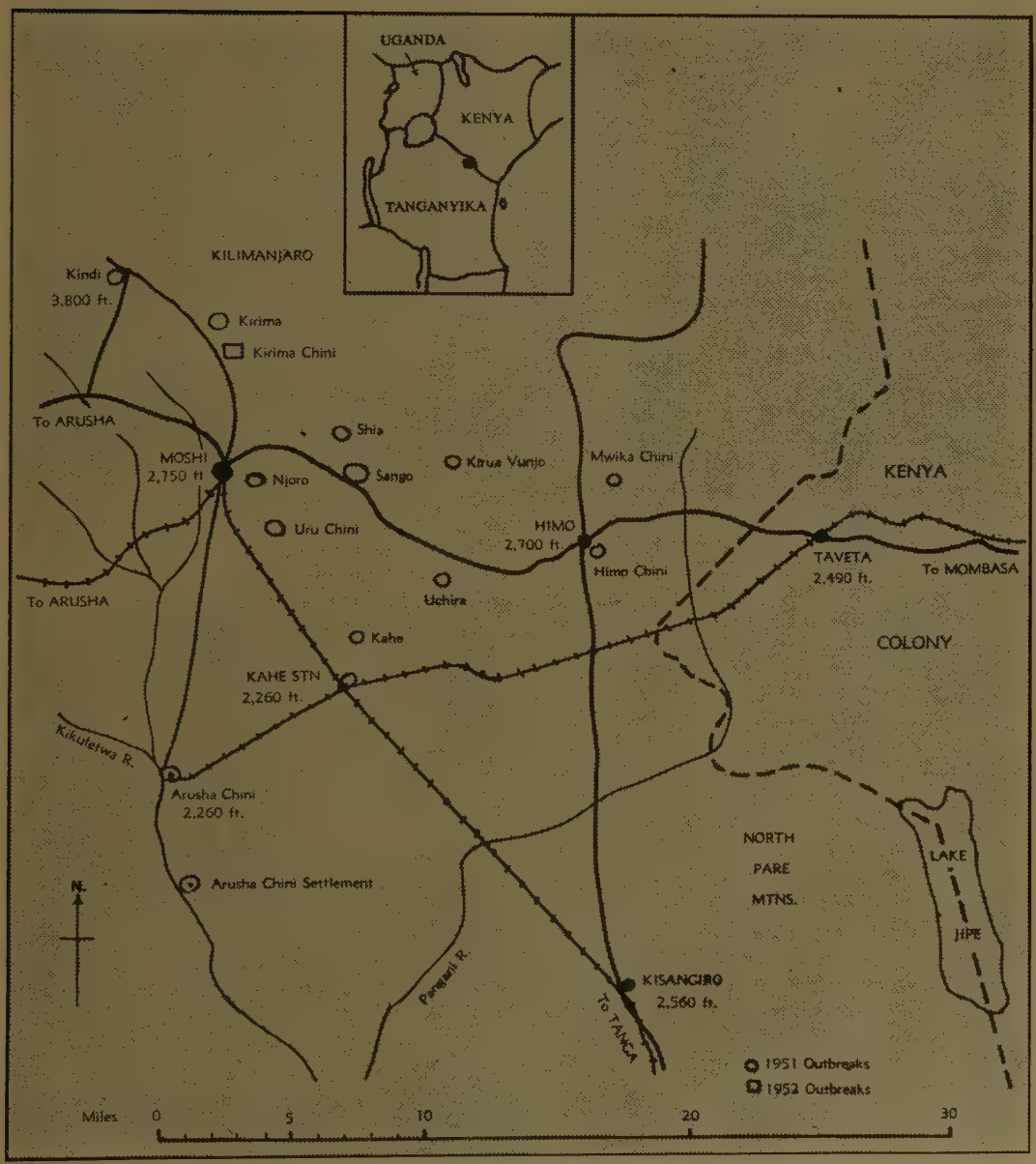

Fig. 1.—Distribution of Banana Wilt in N.E. Tanganyika on 1.1.52
(Endemic areas shown by circles)

Inanambo, is eaten by women only, according to local custom. The varieties used for brewing native beer are *Kisukari kifii*, *Ifwanaiya* and *Ilalyi*, and less usually *Nshonowa*, *Ikonosi* and *Mamweri*. The *Ikonosi* is, with the *Kisukari kifii*, the most popular variety for beer among the natives on the plain. There are thus 11 popular varieties grown on Kilimanjaro; a further 14 are less common.

The Disease

The fungus *Fusarium oxysporum* forma *cubense* which causes wilt can live and persist in soil for many years even in the absence of bananas. The only plants which it can infect are banana and some other species such as Manila hemp in the banana family Musaceae; among the Musaceae only the banana is grown in the Northern Province.

In countries where bananas are grown for export, as in Jamaica and the Canary Islands, the number of suitable varieties is limited, and susceptibility in these is a matter of serious concern. On the other hand, in countries where the banana is essentially a food crop for local consumption wilt disease is not now looked upon as a major problem. In New South Wales, Magee [4] states that wilt, though rather widespread, is of little economic importance, because of the cultivation of resistant varieties. Cheesman [2] states that in Trinidad "The problems of the banana as a local food crop have hitherto scarcely existed, partly because diseases are less serious when the plants are grown as scattered individuals among other species, and partly because so many varieties are available that suitable ones can usually be found for any set of local conditions within the banana-growing districts".

It is confidently expected that in Tanganyika also the replacement of susceptible by resistant varieties will be the ultimate answer to the problem. In the meantime, while the susceptibility of local and other East African varieties is being investigated, our objectives are to destroy infective material and to restrict spread of the disease as far as possible.

Conditions Favouring Wilt

Susceptibility of banana to wilt is related, in the first place, to the genetic constitution of the plant. Secondly, there are a number of biological strains of the fungus with different infective powers; for example, a strain in the Canary Islands can infect Cavendish banana whilst strains in the New World cannot do so. Thirdly, local environment can influence the activity of the fungus in the soil and hence the severity of this disease. These conditions are discussed by Wardlaw [6], who stresses the importance of water supply, aeration and soil acidity, and refers also to temperatures, supply of nutrients and various injurious factors. Controlled irrigation may reduce the importance of the disease, whilst heavy rainfall on stiff soils can promote infection; open light sandy soils also favour the disease. He states that in highly acid soils the fungus undoubtedly reaches its greatest virulence. Untilled, compact alluvial or clay soils are inadequately ventilated and conducive to the disease. Wounding by implements or by banana weevil facilitates entry of the organism.

Infection

The young roots and rhizome are almost invariably the parts first attacked; infection by air-borne spores from pustules on the leaves is said to be much less important. Entry of the fungus takes place through root-bases. Infection through wounds or the basal cut end is largely dependent on water-logging and inadequate aeration. Once the fungus has penetrated to the water-conducting vessels its progress is rapid and it spreads upwards to the stem and laterally to buds and shoots. A plant shows external symptoms some three months after infection.

Dissemination

The most dangerous means of spread of the fungus is the movement of suckers for planting and of banana trash and soil from infected fields. Soil may be carried on the feet, on farm implements and on the roots of plants such as cassava and other root crops often grown under the banana. It may be spread by irrigation water, while rivers could carry diseased material for long distances. Spores, borne in pustules on the leaves, may be carried by wind or on trash.

The rate of spread within an infected area, as has been shown elsewhere, can be either slow or extremely rapid, the latter particularly after a period of rain.

Symptoms

Yellowing, which is one symptom of wilt, is also associated with other diseases, old age, weevil injury, etc., and is in itself not sufficiently diagnostic. In wilt the yellowing commences in the outer older leaves, starting along the edges and spreading to the mid-rib.

Fig. 2.—Plants showing stages of wilt

Fig. 3.—Stems showing splitting

Fig. 4.—Longitudinal section of stem, showing discoloration near edges

Fig. 5.—Cross section of stem, showing discoloration near edges

Fig. 6.—Longitudinal section of rhizome and stem base showing discoloration

Fig. 7.—Longitudinal section of rhizome, stem base and shoot, showing discoloration

A brown colour succeeds the yellow and finally all the leaves are similarly discoloured. As the leaves dry and wither they break and fall over (*Fig.* 2). Depending on the variety, yellowing may be a bright canary unassociated with brown spotting or shredding or tearing. On Kilimanjaro the yellowed leaves do not remain long on the plants, as it is the custom to remove discoloured leaves for cattle food and mulch.

A useful diagnostic symptom of wilt is the occurrence of a longitudinal split on one side (*Fig.* 3), or sometimes on two sides of the stem. The split may be only about 6 in. or 12 in. long, but it may be as much as 6 ft. It may be up to 1 in. or 2 in. deep, and usually involves several leaf bases. However, a split in a single leaf base is normal when a leaf blade is dead from any cause.

The presence of reddish colours inside the rhizomes and stems is a further reliable symptom (*Figs.* 4 to 7). The discoloration usually starts with yellow, but this soon changes to red, brown and purple. A section through the rhizome shows these colours in a ring around the stele or central half; the ring varies in width from $\frac{1}{8}$ in. to $\frac{3}{4}$ in. The same colours are seen in the short exposed lengths of vascular bundles within the stele, and often in the bundles extending from the stele to side buds and shoots. It is not unusual to see secondary rotting extending from the outside of the rhizome inwards; this is a more even grey or brown colour and is not confined to the bundles.

Discoloration in the stem commences at the base and progresses to the top and the outer leaf bases are affected before the inner ones. The colours vary from yellow in the youngest infections to red and brown, and finally almost black in the oldest.

Damage to the fruits is secondary. When the base of the plant is infected, the sap-conducting vessels are occluded by fungus hyphae and the flow of sap is slowed down; the earlier that infection takes place at the roots the greater is the effect on the fruits. Severely damaged fruits ripen irregularly, they are acrid and pithy and may remain small and turn black.

Microscopically the *Fusarium* hyphae may be difficult to find, but the fungus grows readily when infected tissue is planted on culture media in the laboratory. The presence of holes and tunnels made by the banana weevil in many infected rhizomes supports the contention that the fungus easily penetrates tissue injured by this pest.

Control

One of the most essential aspects of control is propaganda amongst the African growers. It is vital that they realize the significance of this new disease and the necessity for concerted efforts and some sacrifice in order to restrict the damage it may cause. No effort has been spared to obtain the understanding and goodwill of the growers in our campaign, though this has required some perseverance. Having in mind that resistant varieties will be available ultimately, we have endeavoured to be lenient and to spare as many fruit-bearing stools as possible by delaying destruction until they are actually diseased. The measures that have been decided upon are however carried out with firmness.

It is difficult for many Africans to grasp the implications of a plant disease which is new to them. The fact that the wilt is new and distinct from the less important Armillaria root rot which they know, has had to be clearly demonstrated and explained. The destruction of plants by hormone weed killers is believed by some to be a form of witchcraft which is being inflicted upon them. These difficulties have resulted in some opposition and, there is little doubt, in the hiding of infections.

However, we have been fortunate in obtaining the confidence of the more educated Africans on the mountain. The Chagga Council, and others, including some of the more obdurate growers, have attended demonstrations in the field and laboratory, and there is little doubt that general confidence and collaboration are increasing. The same problems may be expected elsewhere. Unless they are overcome, there will be delays and frustration.

Resistant Varieties.—The observation of immunity or high resistance in two of the five varieties being grown in the endemic area accords with experience elsewhere, and we are encouraged to believe that further resistant varieties will be found in East Africa. The two unaffected local varieties, *Kinguruwe* (*Kimalindi*) and *Inanambo,* are unfortunately not popular; both are used for brewing beer and for cooking.

Shoots or "bits" have been obtained for trial from Kilimanjaro, Amani, Tanga and Morogoro in Tanganyika and, through the courtesy

of the Directors of Agriculture in neighbouring territories, from Uganda, Kenya and Zanzibar. These shoots have been planted in affected soil, usually on the sites where infected plants had been taken up. Some of the planting material has been unsatisfactory and there may be delay in deciding the susceptibility of all the varieties being tested.

Resistant varieties are required for cooking, for eating raw and for native beer, and must be suited to low, intermediate and high elevations, and other environmental conditions. Should varieties not be found in East Africa to meet all these requirements, it would be necessary to import others from abroad (with the agreement of all four territories); that would entail quarantine at Kew and there would be considerable delay.

Reduction of Spread.—Although it cannot be prevented entirely, efforts are being made to delay spread as much possible, not only to clean land in the endemic district, but to neighbouring districts and territories. All the latter have been warned of the menace and are presumably taking action.

Banana wilt has been gazetted as a disease under the Plant Protection Ordinance, and any suspected cases must be declared. Other rules are being formulated to cover the following precautions, and in the meantime these are being encouraged as far as possible by propaganda.

When affected fields are replanted, no banana varieties which are known to be susceptible are allowed to be planted.

Fruit from affected fields must be consumed locally. Parts of banana (except fruit) from affected fields must not be moved. This refers particularly to banana stems and leaves for cattle food, leaves and fibre for wrapping or tying loads, and material for thatch.

Soil must not be moved from affected fields, and this includes soil on other plants such as cassava and sweet potato roots. Irrigation furrows must not pass through affected areas on to clean land beyond. Precautions must be taken against the movement of soil on the feet of men or animals or on farm implements; animals should not be allowed to stray from affected to clean land. Stocks of disinfectant such as Jeyes' fluid are kept in each affected area, and tins of diluted disinfectant are kept ready for use by labourers and others leaving the affected fields. The difficulty of enforcing this is of course obvious.

Organization.—During these early months the study of the disease and its control has been largely exploratory and in the province of the Plant Pathologist. The Agricultural Officer, Moshi, has been mainly responsible for propaganda amongst the African growers, while his two Agricultural Assistants have been in charge of field work. The Regional Assistant Director of Agriculture, Arusha, and the Administrative Officers have been in touch with the work and have been consulted when necessary. At first all the African Instructors in the Moshi District were diverted to wilt control and learned the procedure; latterly the 15 affected areas have been grouped into seven larger regions, and each of these is under the supervision of one African Instructor. These Instructors are taking over the destruction of infected banana plants, watching for new cases and doing general propaganda work. Outbreaks in new areas are confirmed at the laboratory before any action is taken.

Destruction of Affected Plants.—Infected land cannot be sterilized, but diseased contaminative banana material is destroyed as soon as possible. After trials of different methods, the present practice is to kill the affected plants by hormone weed-killers; details of the method are given below. In order not to destroy more potential fruit bearers than is necessary, only affected stools are dealt with as they appear.

Destruction by Uprooting and Burning.—The digging up of affected plants and their healthy neighbours was the first method tried. Large gangs of labourers were provided by the local Native Authorities, and they worked under headmen with supervision by the Agricultural Assistants. At first the healthy plants within 20 yards from each diseased plant or group of plants were dug up but later only those immediately surrounding affected plants were dealt with. The area was not fenced in, nor declared to be a quarantine area, nor were other crops removed to prevent trespass. Uprooted plants were cut into pieces not more than 3 ft. long nor more than 3 in. thick. Leaves, stems and roots were stacked separately. After two or three months the material was dry enough to burn with what local fuel was available.

This method has serious drawbacks. There is delay in disposing of infected material; much labour is required; the work is slow, and it results in great upheaval and exposure of infected soil. It was certainly unpopular with

the growers, and it was soon abandoned in favour of other methods.

Destruction by Oil Treatment.—This method of killing bananas has advantages over uprooting and burning, and is the method favoured in the West Indies. It is laborious and expensive and did not prove to be very successful here, though further experience might have given better results. The method need not be described as it can be consulted in the literature [5] [6].

Destruction by Hormone Weed-killers.—The application of weed-killers to bananas was first tried in New South Wales [3]. The method was developed as a cheap means of killing old uneconomic stools, and was not applied primarily to stools with wilt, which occurs there. That is however the intention in Tanganyika. Advantages are the little labour required, the simple apparatus, the low cost and the non-disturbance of soil; the latter renders it particularly applicable on steep slopes and near irrigation furrows and paths, though care is required that the hormone is not carried to crops lower down. Care is also necessary during the spraying of hormone solutions that they do not reach other crops. The opposition of some Africans to this method has been referred to above.

Notes are given below on the method as developed in New South Wales and adapted here. The matter of cost is of interest. In New South Wales during the 15 years up to the end of 1950, 34,000 acres of bananas were destroyed by uprooting at a cost of £250,000, that is £7 6s. per acre (much the same as in Tanganyika). The costs for banana destruction (Cavendish variety) by hormone injection and spraying of regrowth are stated to be, for one acre:—

	£	s.	d.
One-half gallon of 10% hormone		10	0
One man for six hours at Sh. 4 per hour (4 hours injecting and 2 hours spraying).. ..	1	4	0
Total cost per acre	£1	14	0

In East Africa the labour cost would be almost negligible, say, Sh. 6 for three man-days. As double the quantities of hormone are required for our larger varieties the cost would be Sh. 20, giving a total of Sh. 26 per acre, which is about one-sixth the cost of uprooting.

The hormone weed-killers used are any of the proprietary forms of 2,4-D or M.C.P.A. Whatever the form of hormone, or the concentration when purchased, it is reduced to 1 per cent for use with an injector in the primary treatment, and to 0.2 per cent for spraying of regrowth.

Two other methods of applying hormones were tried in New South Wales: (i) spraying the foliage: this is more costly than injecting, two pints of fluid being required in place of about two fluid ounces for a (Cavendish) plant; sprayed plants do not fall over as they do when injected; (ii) spraying of cut surfaces after the stems have been cut down; this method is the slowest, but requires only the same amount of fluid as injecting. The sucker regrowth is heaviest, so that later spraying requires more materials. Spraying methods in wet weather are unsatisfactory, whereas injections can be made whatever the weather.

For injecting the hormone fluid, a long, hollow needle fitted to a suitable injector is used. The required quantity is drawn into the injector, and the needle is plunged into the stem at a slightly downward angle just above the rhizome. The needle is withdrawn for 2 in. and the fluid is injected. For a small stem, such as Cavendish, one-half ounce is sufficient, and for a large stem one ounce. Smaller doses are used for other above-ground growths. Buds and the smallest shoots receive a few drops at the tips.

Two or three weeks after injection, the stems fall over and rot. The underground parts are not likely to be killed completely, and new buds and shoots require to be treated once or maybe twice at intervals of several weeks, when new shoots are up to 1 ft. high. For this regrowth a more dilute solution of 0.2 per cent is sufficient and this is applied with a knapsack sprayer. Fallen stems are best piled together to rot and dry out. It should be safe to replant when the old stools have been killed.

In Tanganyika, before injection is undertaken, the owner is allowed to remove the top of a plant above the discoloured infected portion for feeding to his own cattle. It is found that a little leniency helps to maintain the goodwill of the growers.

Care should be taken to wash the knapsack sprayer thoroughly after use, especially before it is used for spraying fungicides, etc., as a

trace of hormone can cause damage. The injector should also be taken apart and cleaned after use.

The Injector.—In New South Wales the instrument used for injecting hormone solutions is a modified tear gas (chloropicrin) jet spray pump, such as is used there for rabbit destruction. One is being obtained for trial here, through the kindness of the Banana Growers Federation Co-operative, Ltd., in New South Wales. Meantime locally purchased sheep dosing pistols are being used; these cost Sh. 45 each. The short nozzle is replaced by a hollow needle, a number of which have been made by favour of the East African Railways, Dar es Salaam, at a cost of Sh. 8/50 each.

The locally improvised nozzle consists of a straight, hollow brass tube, 9 in. long. The space at one end is plugged with a pointed steel tip. The outer diameter of the tube is 8 mm. and the bore 5 mm., though it need not be so wide. At seven-eighths of an inch from the tip there is a hole one-twentieth of an inch diameter at one side. The side of the tube around the hole is flattened and has two grooves running forward towards the sides. Five-sixteenths of an inch from the other end there is a flange with a soft washer, and this is held tightly in the pistol by the nozzle nut. The pistol consists of a cylinder containing a plunger which can be adjusted to allow quantities up to one ounce to be injected. The plunger is operated by a trigger handle working against a spring. A wire for clearing the nozzle of banana debris is kept at hand, as blockages are frequent.

Quantities.—The following tables indicate the use of two locally obtainable hormone weed-killers for injecting and spraying.

(*a*) 30 per cent liquid M.C.P.A. hormone weed-killer:—

(1) Quantities to make a 1 per cent solution for injection—

Liquid hormone 30%	Water to make up to	Large stems at 1 oz. each	Stools*	Acres
Over 1 fl. oz.	1 3/5 pint	32	*10*	
10¾ fl. oz.	2 gal.	320	*100*	
3 pints ..	10 gal. / 5 pints	1,720	538	*1 acre*
1 gal. ..	30 gal.	4,800	1,500	2¾ acres

* Small shoots and peepers are given a few drops at the tips.

(2) Quantities to make a 0.2 per cent solution, for spraying regrowths—

Use 31 ml., i.e. a little over 1 fluid oz., in 1 gallon water.

(*b*) An 80 per cent dispersible powder 2,4-D.

(1) Quantities to make a 1 per cent solution for injection—

Hormone powder 80%	Water to make up to	Large stems at 1 oz. each	Stools*	Acres
2/5 oz.	1 3/5 pint	32	*10*	
4 oz.	2 gal.	320	*100*	
1 lb. 5½ oz.	10 gal. / 5 pints	1,720	538	*1 acre*
7 lb.	56 gal.	8,820	2,757	5⅛ acres

* Small shoots and peepers are given a few drops at the tips.

(2) Quantity to make a 0.2 per cent solution, for spraying regrowths—

Use 11.4 gm. in 1 gallon water.

NOTES ON OTHER DISEASES OF BANANA

A few other diseases of banana which occur in East Africa, some of which might be confused with wilt, are described very briefly below:—

Armillaria Root Rot (*Armillaria mellea*).—This disease is fairly common where banana groves occur on old forest or savannah land. Its presence in banana and the damage it causes are primarily determined by the number of old tree roots in the ground and by the intensity of the rainfall. There is little or no danger to bananas in neighbouring fields. Leaves show an intense yellowing and browning, and the plants eventually die. One distinguishing feature is the presence of white mycelium in cracks or islands within the rhizome and stem base. Control can be effected by taking up and burning affected plants and dead wood in the soil. It is not unusual for Africans to confuse wilt with this disease, and the distinctions require to be pointed out to them.

Marasmius semiustus is the cause of another local root disease common in Uganda. It resembles Armillaria root rot in some respects. Leaves dry up, and brown areas spread inwards in the stem. There is some white mycelium in the stem and bulb. The fructifications are mushrooms, as are those of Armillaria, but the stalk is attached excentrically in the Marasmius. Badly drained and poor sandy soils encourage the disease.

Blackhead Diseases.—In this group of diseases only *Thielaviopsis paradoxa* has been seen, very rarely, and it appears to be uncommon. Conditions which encourage diseases in this group are wounding and weevil injuries, water-logging and shallow rooting. Infected rhizomes show dark water-soaked areas extending from the surface into the cortex. Plants can be protected by good culture. Diseased plants should be taken up and destroyed.

Leaf-spot or Sigatoga Disease (*Cercospora musæ*).—This disease need not be confused with wilt. It starts as spotting on the leaves, the spots being grey, and rather oblong blunt-ended areas; the tissue round the spots turns yellow and gradually the whole leaf becomes yellow and brown and finally withers. It is not common in Tanganyika although it is rather notorious in the West Indies, where it requires to be controlled by copper sprays.

Cigar-end Rot (*Stachylidium theobromæ*).—This is usually of minor importance; it is confined to the fruits which turn grey from the tip downwards, resembling the ash on a cigar. Varieties vary in susceptibility. *Anthracnose* (*Gloeosporium musarum*) is sometimes damaging to the fruit, particularly when the weather is wet and warm; it is encouraged by bruises, particularly on riper fruit.

Bacterial Wilt Disease (*Pseudomonas solanacearum*).—This disease has not been seen in bananas in Tanganyika and only seldom in a few other crops; it is said to be more common in Zanzibar bananas. Apart from the absence of splitting of the stem, the chief distinctions from wilt are to be seen internally: the vascular strands are discoloured yellow to dark brown and not reddish; cut surfaces show an exudation of opaque dark bacterial slime. Heavy and poor soils are conducive to the disease. Affected plants should be eradicated and the use of heavy gas oil is recommended by Smith [5] (quoted by Wardlaw [6], on pages 110–111 of his book).

Conclusions

Wilt or Panama disease of bananas is now established in the Moshi District of Tanganyika. The causative fungus cannot be eradicated, and losses on an increasing scale are to be anticipated, particularly if the disease spreads to the intensively cultivated areas higher on Kilimanjaro.

In the six months since the disease was first observed (18 months since the disease is thought to have started), there have been no reports of other outbreaks in Tanganyika or in neighbouring territories.

The prospects are that new areas of infection will be found in the future, particularly in areas adjoining the Moshi District and probably most severely in areas with high rainfall and with acid soils. Efforts are being made to confine the disease, and it is expected that before long it will be possible to recommend resistant varieties.

It is most important that Agricultural Officers, their African assistants and others learn to recognize the symptoms of wilt and the measures for control which are now in use or which may be developed in the future.

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EUCALYPTUS IN THE URBAN AND RURAL ECONOMY OF UGANDA

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Uganda, like the majority of the East African territories, is a land without natural coal resources, and it depends on the easy availability of wood fuel, both for its domestic needs and commercial enterprises. In the early days of the Protectorate's history there was little cause for alarm that the supply of natural bush was not sufficient for all possible contingencies. This happy state of affairs was not to last. The introduction of cotton, with its ancillary ginneries and the clearing of the natural bush from the land for cotton plots, soon gave rise to a well-founded suspicion that some other form of wood fuel would have to be sought. Over a long period the situation was no doubt aggravated by the increased birth rate and declining death rate resulting from better medical facilities, which gave rise in turn to a land pressure not known formerly and a further clearing of the indigenous trees for food plots.

The result to-day is that in the majority of districts it is doubtful whether bush fuel is available to minor townships within less than ten miles and to major townships within a far greater distance. Eucalypts of unknown species were introduced to Uganda in 1909–1911, but no intensive or planned planting appears to have been carried out until 1916. In this year some 12 acres were planted at Mutai, in the Eastern Province, with *E. rostrata, E. hemiphloia* and a non-Eucalypt species *Prosopis juliflora.* There would appear to be some evidence however that the so-called *E. rostrata* was very probably a hybrid with *E. tereticornis.*

It was reported that in March, 1916, the *E. rostrata* (*E. tereticornis* hybrid) raised enthusiastic expectations but no further details are available [7]. This is probably due to the fact that *Markhamia platycalyx* became the chosen tree for planting, and when the Mutai plantation was inspected by the writer in 1947 it consisted of a semi-natural type of forest, due to the invasion of indigenous species such as *Teclea nobilis,* with a small patch of large Eucalypts in one corner of the area, which was probably a remnant from the 1916 plantings. In 1918 fuel plantations were started at Kampala and Entebbe with five acres of a mixture of species some of which were without doubt gums [1].

Between 1926–1929 the plantations were extended considerably with Eucalypts, the seed of which had been obtained from roadside trees. Though the source of supply is open to suspicion the type form as shown by the trees in the Kampala plantations to-day is certainly near *E. saligna.* This uniformity may be explained by the fact that irregularities in the early planted species would appear to have been smoothed out to a large extent by the importation of pure seed from Kenya in 1942. In this year Kenya experience suggested that *E. saligna* was the most suitable tree to plant for both fuel and pole requirements. There were large importations of seed, which was probably the closely allied *E. grandis* but which is known and planted as *E. saligna* throughout Uganda to-day. It would appear also that at about the same time a certain amount of pure *E. saligna* and *E. robusta* strain seed was imported from Australia.

From 1926 onwards the African Local Governments began to take an interest in exotics as a form of fuel supply for rural and village areas.

State Control and Commercial Enterprise

With the object of "the greatest good to the greatest number", planting proceeded apace from 1926 onwards under State control. It should be noted however that these efforts were mainly directed by administrative officers rather than technical officers, as the latter had yet to be brought up to full strength. These operations resulted in plantations of mixed Eucalyptus species, which have in many cases given good yields both of poles and fuel but which are not entirely desirable from a forestry viewpoint. In the Eastern and Buganda Provinces, however, it has been the rule to plant the accepted and favoured Uganda *E. saligna* type under the direct control of trained Forestry Officers.

It can thus be said that as a result of administrative action in those rural areas where the soil and elevation were suitable,

small Eucalyptus plantations have been formed at all chiefs' headquarters, while the urban development of plantations has mainly been the concern of the Forest Department.

With the adoption of the Development Plan for Uganda, 1946, and the recruitment of additional forestry executive staff, the planting of Eucalyptus received a further impetus along well planned lines, and its future development was defined as follows: "The requirements of fuel and building poles cannot be met from the main forest areas, but are best provided by plantations established in various parts of the Protectorate. The tree most suitable for this purpose through most of Uganda is the Eucalyptus, which is cut on a rotation of eight years. Experience with Eucalyptus has shown that receipts in the ninth year more than cover the cost incurred during the preceding eight years. The trees are then coppiced and yield a steady revenue of about 3 per cent per annum on the original capital expenditure. It is intended to develop these fuel and pole plantations at the rate of 440 acres a year for eight years, the plantations being situated near Kampala, Fort Portal, Hoima, Arua and Masindi" [2].

Prior to this statement of policy, there had been planting close to Kampala since 1927. Apparently the view held at that time that the better land should be reserved for agriculture, and that wet or even swamp sites were suitable for Eucalyptus, resulted in the choice of a planting area of marginal soils and papyrus swamp. With extensive artificial drainage and other aids, establishment was eventually achieved on this difficult site and by 1951 there were 2,373 acres of *E. robusta*, 1,048 acres of *E. saligna*, and 30 acres of *Markhamia platycalyx*. The *E. robusta* was planted in the swamps, which have now in many cases dried out sufficiently for this species to be replaced by the faster growing *E. saligna*. Under the above conditions these plantations must certainly have been very expensive to put in and there is little doubt that to get the maximum financial return from a Eucalyptus plantation it must be formed on the best available soils. Much of this planting was carried out with stock raised from the imported Australian Eucalyptus seed.

These plantations were put in with the object of forming "a permanent source of commercial fuel" [3]. Apart from sporadic attempts by Missions to put in plantations, it was a long time before commercial enterprise realized the dangers of the vanishing natural bush supply and the advantages of having their own exotic fuel plantations close to the scene of their operations. Kakira Sugar Works was one of the first firms to realize both the financial and utilitarian advantages of owning their own Eucalyptus plantations and as a result they began planting operations at Mutai in 1944 with a 50-acre block and by 1947 had 972 acres under a very fine Eucalyptus crop.

Individual enterprise was encouraged by the distribution of Eucalyptus seedlings to farmers by the African Local Governments. The results from this varied greatly from district to district, and it was reported that "peasant planting has so far proved effective only in Kigezi and in parts of Ankole and Toro Districts. In Toro peasants' plots are pleasantly numerous" [4]. There seems little doubt that, in some districts, this lack of enthusiasm for peasant planting will disappear with an ever-increasing fuel and pole shortage. In other districts, however, such as West Nile, where the peasants have long been satisfied with the local grasses as a fuel, propaganda will have to play its part to a large extent.

Uganda is a land of lakes with associated swampy valleys, ideal as breeding grounds for the malarial mosquito, and no account of the economy of the Eucalyptus would be complete without mention of its use in conjunction with anti-malarial works. In 1929 extensive afforestation of papyrus and other swamps at Tororo and Soroti was carried out with *E. robusta*; the Tororo plantations were put in with the additional objective of supplying the Railway with fuel. On the whole the results have been far from happy, as these plantations have been expensive to put in and in many cases only semi-establishment has been achieved. Indeed it soon became apparent that the medical objectives would clash with those of forestry when felling and extraction operations raised the water table and brought back a return of the malarial condition. Average yields from these plantations have been low, and swamp planting can never be an economic proposition. It has indeed been stated that "from the forestry viewpoint, anti-malarial plantations are a very distinct liability and not an asset" [5]. It is possible that a light track railway may solve some of the medical objections to felling.

Utilization

Though the majority of the products from the Uganda Eucalyptus plantations have gone into fuel and building poles, other uses are being investigated and in 1949 some 3,000 *E. saligna* poles were taken from the Kampala plantations by the Uganda Electricity Board as transmission poles. Treatment prior to use included the hot-and-cold open-tank method with Wolman Salts. It was noted that "it is unfortunate that the commitments of the Board did not permit a normal period of seasoning before treatment, and it is feared that cracks which appeared subsequently will allow the entry of rot and termites" [5]. In actual fact it would appear that however carefully Eucalyptus timber is seasoned a certain amount of cracking cannot be avoided but that the cracking does not interfere with the strength or working qualities of the product. In the same year *E. saligna* was tested as a pulp for paper manufacture. The results were entirely satisfactory but it was stated that "East African consumption of paper is insufficient to warrant the erection of a factory to supply the internal market alone and, if the product is to be exported, manufacturers would naturally prefer to work nearer the coast" [5].

In the West Nile District of the Northern Province Eucalyptus is much favoured by the Missions both for heavy constructional work and for the manufacture of cheap furniture, doors, window frames, boxes, etc. Its usefulness in these respects might be made known in other parts of the Protectorate, where the higher quality timbers such as Mahogany and Mvule are often used for such projects.

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Bukigai Plantation, South Bugishu. Planted 1943, 8 ft. by 8 ft. Average height 1951, 110 ft. and g.b.h. 46 in.

PINEAPPLE PROPAGATION

By H. R. Evans, Department of Agriculture, Kenya

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Following the development of a pineapple canning industry in Kenya, the acreage under this crop has rapidly expanded but a serious limiting factor is the lack of good planting material. In view of this, steps were taken to investigate less known and also new methods of increasing the production of planting material. These methods appeared to have advantages over the more orthodox but slower methods of reproduction by slips, suckers and tops.

Work on increasing the output of pineapple planting material was undertaken in the West Indies during 1929 [1] where promising results were achieved by means of cutting non-fruiting stems into discs of one-fifth of an inch thickness and planting them in prepared open beds. By this method it was possible to obtain 80–100 plants from each stem within six months, but preliminary investigation in Kenya of propagation by discs has not produced such successful results as were achieved in the West Indies.

The investigations described in this paper were designed to determine whether any other part of the pineapple plant could produce quicker and more successful multiplication under local conditions. The materials and methods used were as follows:—

(*a*) "Discs" produced by cutting up mature stems.

(*b*) Fruit tops and suckers split into small vertical sections.

(*c*) Mature fruit top leaves.

Stem Discs

The technique adopted was similar to that used in the West Indies. Unfruited, mature stems were cut up into discs of $\frac{3}{8}$ in. to $\frac{1}{2}$ in. thickness and planted in unshaded open nursery beds where they were embedded in a sand cushion to a depth of 1 in. Watering was carried out daily during all dry periods. As shoots became established on their own roots (*see* Fig. I) they were removed from the parent disc either by making a wedged-shaped cut or by a gentle pull, whichever means best suited the extent of attachment. These shoots were then transplanted in new nursery beds.

Fig. 1.—Shows rooted shoots produced from a mature stem ready for removal. Right, a removed shoot.

Table I shows shoot production results.

Table I

(*Number of discs set was* 87 *produced from* 10 *stems*)

Examined at (days)	46	138	165	254	342
No. discs producing shoots ..	3	48	52	52	52
Total number shoots produced	4	65	93	122	130
Shoots produced per stem ..	0·4	6·5	9·3	12·2	13·0

Of the 130 shoots produced, 23 died before rooting. The remaining 107 were successfully transplanted in the nursery in three batches. The first batch of 48 shoots was transplanted 165 days after insertion of the discs. At 14 months these had attained a leaf spread of 14 in. The second and third batches were transplanted at 280 and 366 days respectively.

The final average multiplication rate was 10.7 shoots per stem.

Frame Trials.—The "disc" method of propagation was also tried in closed, glass covered propagating frames. Discs were cut up as described earlier and inserted in a 50 per cent mixture of decomposed coffee hullings and sand. Humidity in the frames was maintained at a high level by spraying daily with an "Eclipse" hand syringe. Out of the 20 discs

inserted, 1 disc produced 3 shoots, which were observed after a 43-day interval.

Fig. 2.—Left to right.—A shoot from a mature stem disc. at 6 months. A full top prepared for splitting. 6-month-old, one eight, fruit top section. (Note.—The scale object is an East African shilling.)

Discs quickly showed signs of decay following insertion and in 120 days all except one were destroyed. If the discs had been treated with potassium permanganate solution as used by Waters [1], greater success might have been achieved. Incidentally, as will be seen later, fruit top sections planted in the same frame about the same time showed no signs of decay whatever.

The "disc" method of propagation is promising but shoot production is considered rather slow. As the condition of the parent material may have an important bearing on shoot production, further investigations should be designed to determine in what condition the stem should be to produce best results. Clearly further investigations under glass are desirable, for there are indications that shoots may be produced more quickly than under open air conditions. Unless shoots were produced much more quickly and abundantly, however, propagation under glass would be far too costly.

Fruit Top Sections

Fruit tops were split into small vertical sections. The sections were produced by cutting upwards through the basal tissue. Sections were then dibbled into open prepared beds where they were watered daily by can during all dry periods. Several different trials were planted to determine:—

(1) Whether sections of fruit tops could be propagated and if so what size sections would produce best results.

(2) The possibilities of establishing sections by planting in the open during the long rains season thereby reducing costs.

(3) The effect on shoot production of using dried out tops instead of fresh ones.

(4) The possibilities of rooting sections of suckers as opposed to fruit top sections.

(5) The effect of hormones on fruit top sections.

(6) The results of frame culture as opposed to open bed methods.

Fruit Tops.—Twelve fruit tops were split up into 8, 12 and 26 sections per top. Table II shows the results.

Table II

Sections per top	Examined at (days)	% Shoots produced
8	36	11·0
	139	87·0
12	36	26·0
	139	42·0
26	36	30·0
	139	30·0

Observations revealed that the 26 and 12 sections per top frequently became exhausted before roots could be produced on the new shoots. Moreover, the small sections, even though roots were produced, often remained stunted. The eight sections per top when established made good progress and after 392 days had attained a leaf spread of 10 in.

The results of this trial show that propagation by fruit top sections is superior to the "disc" method and that propagation by eight sections per top produces much better results than smaller top sections.

Fruit Top Sections.—This trial was designed to determine the possibilities of establishing fruit top sections during the rains. Eight tops cut into eight sections per top were planted as the rains set in. In 63 days 43 per cent had produced shoots on a rainfall of 23.61 in. Rain fell on 41 days out of the 63.

In 100 days, the percentage had risen to 95 per cent on a rainfall of 31.97 in. Rain fell on 59 days out of the 100.

After a lapse of 200 days the shoots had produced a leaf spread of 5 in.

Results show that this method of planting during the rains can be very successful. This method deserves consideration in view of the saving in labour, supervision and water.

Dried Fruit Tops.—This trial was designed to determine if fruit tops dried out in the full sun for a period of 21 days would produce shoots more quickly than fresh top sections. The drying out of pineapple planting material is a common feature in field culture. Each top was split up into 8 sections after the drying out period.

TABLE III

(12 *tops were used in the trial*)

	Fresh Sections		Dried off Sections	
Examined at (days) ..	54	85	54	85
Per cent shoots produced	25·0	81·0	12·0	93·0

After a 200-day period no marked differences in the vigour of either batch of plants was observed. The leaf span of each batch during the period attained 10 in.

Sections of Suckers.—These were planted to compare performance with that of fruit top sections. To be of comparable size with fruit top sections, sucker sections could not be split into more than four sections per top, each top consisting of eight sections. The trial was planted during the rains and no additional water was supplied by artificial means.

TABLE IV

(15 *suckers and* 8 *tops were used*)

	Sucker Sections			Top Sections		
Examined at (days)	90	124	155	90	124	155
% shoots produced	12·0	26·0	32·0	75·0	85·0	90·0

The top sections produced very much more vigorous growth than the suckers. The leaf spread of the top sections had attained 6 in. in 155 days while that of the sucker sections had scarcely started. Rainfall recorded before planting was 4.92 in. and the total over the trial period was 30.88 in. Rain fell on 33 out of 155 days.

There is no doubt that propagation by eight sections per fruit top is superior to propagation by suckers, moreover, the multiplication rate of fruit tops is twice that of suckers.

Fig. 3.—Shows progress of complete fruit tops and 8 sections per top after 7 months.

Hormones.—The hormones used were B-Indolyl-Butyric acid at a concentration of 0.125 grms. in 100 cc. made up of 50 per cent tap water and 50 per cent ethyl alcohol; Seradix B. No. 1; and Hortomone A. Cuttings were made from 18 fruit tops by splitting into 8 sections per top.

TABLE V

(*Percentage of cuttings producing shoots*)

Examined at (days)	38	68	99
B–Indolyl–Butyric acid ..	17·0	97·0	97·0
Seradix B. No. 1 ..	31·0	88·0	97·0
Hortomone A.	24·0	88·0	91·0
Control	30·0	88·0	97·0

Cuttings were watered by can throughout the trial during all dry periods. After a period of 353 days there was no marked difference in the vigour of plants as a result of hormone treatments. The leaf spread of all cuttings was 12 in. Hormone substance in the concentrations used appear to have had no effect in accelerating shoot production.

Frame Culture.—A frame trial of 14 sections per fruit top was inserted to determine the possibilities of propagating small top sections under glass.

TABLE VI

(6 *tops were used in the trial*)

Examined at (days) ..	34	74	118
Per cent shoots produced	25·0	78·0	100·0

The young plants were hardened off and transplanted in open beds after a period of 136 days. At 392 days the plants had attained a leaf spread of 14 in.

Nothing worthwhile appears to have been gained by frame propagation when compared with the open bed performance of fruit top sections.

Leaf Cuttings

These were made by removing leaves from fruit tops with a sharp upward pull. Care was taken to ensure that no attachment tissue was retained by the leaves. Of 36 leaves inserted in a propagating frame, the rooting medium, which consisted of a 50 per cent mixture of coffee hullings and sand, only two produced a shoot each in 120 days. A second trial produced identical results.

An interesting outcome of this latter trial resulted from the planting of the soft base tissue after the leaves had been removed. This piece of tissue produced a completely new rosette of leaves in 22 days and after a period of 270 days had attained a leaf spread of 9 in.

Multiplication by leaves appears to have little promise.

Summary and Conclusions

Results show that propagation by fruit tops split into eight sections per top is superior to the mature stem disc method. Maximum shoot production by discs was not reached until 342 days, whereas maximum shoot production by top sections was reached in 93 days. Propagation by the disc method, however, requires much more investigation under both outdoor and frame conditions; the composition of the rooting medium, moisture conditions and shade intensity requiring particular investigation.

With regard to the size of fruit tops, Table I clearly illustrates the superiority of the eight sections per top size. As eight sections per top propagates so successfully there appears to be no object in utilizing larger sections and thereby reducing the multiplication rate per top.

Nothing appears to be gained by the drying out of fruit tops prior to planting. Though a slightly higher shoot percentage was recorded over the fresh sections, this is not considered sufficiently significant to warrant the drying out process.

Top sections are clearly very much superior to sections produced from suckers. Not only do top sections produce shoots more readily but the multiplication rate of an eight section fruit top is twice that of a sucker which can only be split into four sections.

Fruit top sections may be successfully established during the long rains if rainfall is adequate and well distributed.

Of the hormones used in the trials, none produced any marked improvement over the untreated control. Much more investigation is required, necessitating the application of a greater range of hormones in varied concentrations.

The experiments described show that fruit tops cut into eight sections per top could be successfully utilized to accelerate the output of pineapple planting material. For the multiplication of selected plants, propagation by suckers, and stem discs would, of course, prove an invaluable adjunct to the use of fruit top sections.

The method demands nursery conditions until the young plants are sufficiently advanced to be planted in the field, but although nursery treatment normally requires considerable attention, planting during the long rains reduces labour and supervision to a minimum.

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PASTURE MANAGEMENT IN UGANDA IN RELATION TO WESTERN EQUATORIA

By J. R. Catford, Ministry of Agriculture, Sudan

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This note is written following a visit to Uganda in June, 1951, made by courtesy of the Department of Agriculture of the Protectorate, with the intention of studying work being done there on the establishment and management of pastures, and of attempting to assess its applicability to the western areas of Equatoria.

No attempt is made to give an exhaustive account of the basic research which has led to the now current policy of ley farming, since this is already available in literature emanating from the Uganda agricultural research institutes. Nor has it been thought necessary to describe in detail various agricultural practices and methods typical of Uganda but inapplicable to Equatoria; these are readily obtained by references to "Agriculture in Uganda", edited by J. D. Tothill.

After a brief topographical, vegetational and climatic comparison of the two territories and a statement of the problems of land usage in both cases, the relevant work of the Uganda experimental stations and extension areas visited will be examined critically and discussed in relation to the Sudan problem. Some suggestions are made for trials which could be carried out in Meridi.

Topographical, Climatic and Vegetational Comparisons

With the exception of small areas of the country covered by forests or papyrus swamps, the vegetation of Uganda is essentially dominated by grasses. In most areas abandoned cultivations, destumped by the plough, do not revert to secondary forest as in Equatoria and elsewhere in the wetter tropics, but to various types of grassland. Since the Protectorate has supported a fairly dense population for a long period, this process has by now been completed in most parts of the country.

The grasslands of Uganda have been roughly divided into ecological zones, each characterized by a series of grasses and although the division is somewhat arbitrary in that the zones grade from one to the other, it offers a working guide to the different agricultural regions of the country, and each region is clearly a function of the prevailing conditions of topography and climate. The two most important zones were visited.

The *Long Grass Zone* comprises most parts of Uganda between 3,000 and 5,000 ft. where the rainfall is more than 45 in. per annum and is also fairly evenly distributed. The zone is dominated by elephant grass (*Pennisetum purpureum*). Where its growth is unchecked by human agency, this species grows as practically pure stands to a height of 12 ft. or more. It is largely responsible for building up soil fertility over large areas of Uganda (*vide* writings of Thomas, Martin and others) and, due to this regenerative action of the grass, parts of the country such as the district north of Lake Victoria have supported a dense native population for a long period. Spear grass (*Imperata cylindrica*) is an early invader when overgrazing has occurred as is the even more pernicious couch grass (*Digitaria scalarum*) (known locally as "Lumbugu").

The *Short Grass Zone* includes most of the rest of the country that is below about 6,000 ft. and has less than 45 in. of rainfall. The term is relative, and is used to describe all grasses shorter than elephant grass although many grow to above 6 ft. in height. *Hyparrhenia* is the dominant genus for the whole zone, of which various species (e.g. *H. rufa, H. cymbaria, H. diplandra,* and, the most valuable, *H. filipendula*) are characteristic of sub-zones. *Brachiaria* species (and especially *B. decumbens*) are common "bottom grasses"; *Setaria sphacelata* and *Chloris gayana* are widely distributed, while *Panicum maximum, Sporobolus spp.*, and *Andropogon spp.*, are often dominant locally. *Imperata cylindrica, Cynodon dactylon* and *Eragrostis spp.*, are among the most common weed grasses of the zone.

By comparison, the western portion of Equatoria does not embrace a wide range of conditions. Its annual total rainfall of between 45 and 55 in. is that of the drier limits of the Uganda long grass zone though the distribution is less even. The altitude of the Sudan region is considerably less, being at most 3,000 ft. and mainly little over 2,000 ft. The

vegetation is dominantly broad-leaved woodland with much bush and little grass; after cultivation it reverts to secondary woodland in competition with tall grasses. *Pennisetum purpureum* occurs, but in general the region is more nearly comparable with the Uganda short grass zone. *Hyparrhenia spp.* (mainly *H. rufa*), *Panicum maximum* and *Imperata cylindrica* are common, but *Chloris gayana* and *Setaria sphacelata* are rare.

Comparison of Problems of Land Usage

The major and all-important difference between western Equatoria and most of Uganda is that the former has virtually no domestic animals except poultry, whereas the latter supports large and ever-increasing herds of cattle, sheep and goats. Under primitive conditions, uncontrolled grazing on land outside the arable areas (chiefly on swamp fringes and areas of poor or shallow soil) was the general rule, but the increases in land under cultivation and in the head of stock kept have brought about a concentration of grazing on more restricted areas, which are often further supplemented by the use of arable land in the resting stage. The natural grass cover which appears on abandoned cultivations is generally insufficient to provide protection against erosion and regeneration of fertility as well as provision of forage for stock. Research on the subject in Uganda has aimed at overcoming this adverse state of affairs.

The problem in western Equatoria is simple by comparison, and at present scarcely touches upon the native farmer. Without livestock to maintain he is only aware of grass as one agent in the regeneration of his fallowing land and, when this stage is passed, as a weed in his cultivations. Apart from long-term considerations of livestock introduction, the question of immediate interest is the possibility of replacing a long resting phase under bush fallow by a considerably shorter one under grass fallow, which is so successful in Uganda.

Dairy farming in western Equatoria has hitherto been the concern only of Government and semi-governmental institutions on certain stations, largely as an amenity to Northern Sudanese and European staff; beef production is also envisaged. In this case the problem is that of supplying maintenance and production rations to cattle in the most economical manner and also that of confining the stock to the smallest possible area in the interests of land economy within a township, of avoidance of tsetse fly areas, and of generally improved supervision by senior staff.

It will be argued in a later section that these two questions are not independent of each other. With their resolution in mind, the relevant work of the Uganda experimental stations visited will be examined, with reference also to those extension areas in which the recommended practices are being put into use.

Uganda Short Grass Zone

The principal experimental station for the zone is at Serere on the south-western peninsula of the Teso district in the Kioga basin. A model dairy herd is maintained there and in conjunction with it a beef herd for participation in the very full range of grazing trials which are undertaken. Of particular interest, also, is a long-cycle fertility experiment which is described below. The findings of Serere are tried out in a more practical and less theoretical manner at Ngetta Farm, Lira, in the Lango district, which is virtually run as a model or demonstration farm. Native farms in the Teso and Lango districts were also visited, as were small mechanical cultivation schemes and areas selected by the Department of Agriculture for special attention.

A good indication of the agricultural potentialities of the zone, and of experimental results obtained, may be gained from a brief study of the "fertility experiment" now in its sixteenth year at Serere. Six different rotations are compared, each having five shifts but with resting periods varying from one to three years (and with cropping periods thus varying from four to two years). Each shift of each rotation is subdivided into three plots for different levels of application of farmyard manure. (The applications are 0, 2½ and 5 tons per acre, applied always in the second year of cropping.) The experiment has thus in effect 90 different treatments in every year; the whole is replicated five times so that in any given calendar year a complete set of 90 plots can be seen. The resting periods of the rotations are treated in a number of ways; for example—

(i) Sown with *Chloris gayana* and grazed.
(ii) Sown with *Chloris gayana* and not grazed.
(iii) Sown with a green manure crop subsequently cut as a mulch.
(iv) Sown with a green manure crop subsequently dug in.

(v) Alllowed to revert to natural vegetation and grazed.

(vi) Allowed to revert to natural vegetation and not grazed.

The respective yields of the rotational crops are used as an index of the success or otherwise of the fallow management adopted. Weekly liveweights of all stock engaged in grazing the fallows are also recorded.

Among the major results emerging from this experiment are the following:—

(*a*) The effect of farmyard manure is marked, and there is a residual effect on up to five crops subsequent to its application.

(*b*) Judicious grazing of any fallow has no markedly adverse effect on subsequent crops; heavy grazing has a more harmful effect when the fallow carries a spontaneous natural cover than when it is sown with *Chloris gayana.*

(*c*) There is no great difference in liveweight gain between stock grazed on the *Chloris* and others on the natural fallows. The former, however, is fit to carry stock sooner than the latter.

(*d*) After 15 years there is little evidence of progressive soil exhaustion even in the rotation having only one year of fallow out of five; the mean yields are, of course, substantially lower. It must be pointed out, however, that the small experimental plots are adequately protected against soil wash by wide paths planted with *Paspalum notatum.*

Grazing trials on many pure stands of grasses and on some grass mixtures have been carried out at Serere for many years. *Chloris gayana* has emerged as the most suitable species and is the only one at present recommended by the Department for extension work in the zone. At Serere a second species, *Botriochloa petusa* (not to be confused with the unpalatable, aromatic and unnutritious *B. glabra*), is still under trial and may prove to be more suitable than *C. gayana* for the drier areas. No satisfactory permanent pasture has yet been evolved.

These and other results have led to the formulation of a ley rotation thought suitable for the zone, and on which the Ngetta Farm is now being run. There are six shifts, thus:—

First Year.—Cotton.
Second Year.—Eleusine (sown dry in March) followed by, or interplanted with, tepary bean and/or pigeon pea.
Third Year.—Groundnuts followed by dura.
Fourth Year.—Chloris gayana ley.
Fifth Year.—Chloris gayana ley.
Sixth Year.—Chloris gayana ley.

All cultivations are done mechanically; a normal opening consisting of a ploughing and a cross-ploughing, followed, if necessary, by a discing. The *Chloris* ley is sown, where possible, in October or November in the third year at a seed rate of 30 lb. per acre, and is then ready to carry stock by June of the fourth year. Each shift covers a block of six acres; in the fourth year, and before grazing begins, blocks are divided into six one-acre paddocks which are fenced with five strands of barbed wire carried on wooden or concrete posts (electric fencing has not proved to be very successful); piped water is laid on. The acre paddocks are then grazed in rotation by growing bullocks which spend ten days in each one in turn, thus taking two months to complete the cycle and return to the first paddock. Groups of five bullocks each have been successfully carried in this manner all the year round on a six-acre block (equivalent to 0.8 beasts per acre), maintaining a satisfactory liveweight increase. Cutting over the paddocks with a mower set high once or twice during the rainy season has been found beneficial but not essential.

Chloris gayana leys into which *Brachiaria decumbens* stolons have been interplanted (at a typical spacing of 1 ft. by 2 ft.) have also been tried. Good bottom cover was obtained which would be of benefit on sloping land (the Ngetta Farm is flat) but no appreciably increased rate of liveweight gain was recorded. *Hyparrhenia rufa* leys have also been used at Ngetta, but their management has not proved as simple as that of those sown with *Chloris gayana.*

Uganda Long Grass Zone

For this zone the principal experimental station is at Kawanda, some nine miles west of Kampala, where the original research on the theory and practice of grass fallow management was carried out. Investigations having passed the purely theoretical stage, the work is now in the extension phase and is being followed up by trials on native holdings in the surrounding area and by progressive local farmers who are voluntarily adopting methods

of mixed farming advocated by the Department. Several of these farms were visited in the Kyaggwe area, and are referred to below.

Work continues at Kawanda on the management of *Pennisetum purpureum*. The productivity of the species has been ascertained by weighing the gross green matter obtained at regular cuttings, and further shown to be at a maximum when the interval between cuttings is about three weeks. The productivity is also greatly increased by planting the grass in rows (the optimum inter-row spacing being about 2 ft.) rather than in close stands. This finding has its application when the grass is sown for ensilage making, for which it is the species *par excellence* when in a young and leafy condition. Several strains of the grass exist.

Very satisfactory pastures composed of *Chloris gayana* and *Pennisetum purpureum* have also been obtained. These were established by broadcasting seed of the former and then immediately digging in short sets of the latter which had been previously scattered fairly thickly over the ground. When kept closely grazed, the *P. purpureum* develops a surprisingly recumbent habit, and may prevent the intrusion of weed grasses to which the *C. gayana* element normally gives place after four or five years. So long as tall growth is assiduously restricted, a pasture of this sort can be maintained permanently.

Paspalum notatum offers the only other example of a "permanent pasture" grass, but this species has the practical disqualification of needing to be established by planting as opposed to seeding; in addition its palatability is in dispute.

The short life of *Chloris gayana* has been a disappointment both in the long and in the short grass zones: three years is its maximum period of dominance in a pasture, and thereafter weed grasses intrude rapidly. The general opinion is that the expression "permanent pasture" is a contradiction in terms: in the tropics, grasslands of a permanent and unchanging composition are normally of low stock-carrying capacity, while those which qualify as pastures in the sense of being palatable and nutritious to stock are usually short lived and deteriorate rapidly.

In the Kyaggwe country of Buganda Province, an area selected for special development on a peninsula of Lake Victoria some 35 miles south-west of Kampala, mixed ley farming of a high order was seen. Here the original practice of shifting cultivation (which had, in common with Equatoria to-day, a seven or eight-year resting period) has largely ceased. Many of these prosperous Buganda farmers own herds of up to 30 cattle (including draught oxen) and some have brick-built houses and cowsheds. The banana garden and coffee plot, features of the original system, are permanent; the rest of the farm is divided into blocks of a number to correspond with the shifts of the rotation. A typical rotation is: cotton in the first year followed by two or three years of food crops and three or four years under grass. Many of these farmers are now fencing their paddocks with barbed wire; three strands is usually found sufficient, carried on green stakes (intended to take root) of such trees as *Ficus spp.* (Barkcloth). It may be mentioned, in passing, that so far no satisfactory species for a stock-proof hedge has yet been discovered in Uganda.

The idea of fencing and controlled grazing is usually accepted by the farmers before that of actually sowing selected grass species into the fallows, but in time, and as the merits of the system become obvious, this too is adopted. Most of these farmers have their own implements (often including British made iron ploughs) for use with draught oxen, but they are also keen to avail themselves of tractor and implement sets on hire from the Department of Agriculture. Ten acres is the minimum area for which a set can be hired (although individual fields may be down to one acre in size). The rates charged per acre in 1950-51 were Sh. 24 for first ploughing and Sh. 18 for second ploughing or hire of disc tiller, disc harrow, Rotovator, ridger or cultivator. It is perhaps not irrelevant to mention other details and conditions of these mechanical cultivation facilities. Some days before the set is due to arrive, a member of the Department's field staff makes an inspection to ascertain that complete destumping has been carried out (a hand ratchet winch is usually used, and this also can be hired), that fields are laid out across the slope of the land and are not more than 30 yd. broad or less than 160 yd. long (this making up the minimum one acre field), and that the grass cover has been slashed and burned. Hire charges are collected in advance.

Manuring is a final aspect of this mixed farming system which must be mentioned. The direct and residual value of farmyard manure to arable crops and in the management of pastures has been reliably established, with

statistical significance, in field trials. A convincing visual demonstration was also seen in paddocks of *Chloris gayana* (both as pure stand and in mixtures) at the Veterinary Research Station, Entebbe, where work on pastures has also been carried out. Indeed, with timely applications of farmyard manure, artificial fertilisers and lime, and with judicious grazing and cutting, a *C. gayana* paddock has been maintained without deterioration for six years. Unfortunately the quantity of farmyard manure forthcoming from stock maintained on a self-contained mixed farm is unlikely to make an appreciable difference to crop or grass yields when distributed over the whole farm and there is the additional problem of the change in intensity of grazing required as between wet and dry seasons. These problems, aggravated by the traditional (and valuable) practice of applying heavy dressings to the banana gardens in Buganda, have not yet been resolved.

Discussion

Experience in Uganda under conditions similar to those of western Equatoria, suggests that the following considerations may apply in the Sudan region under discussion.

Pastures for dairy herds kept on Government stations could certainly be improved greatly by rotational grazing and probably by the introduction of selected species of grass which are either non-existent or sub-dominant in the natural pastures. Rotational grazing is impossible without adequate fencing, for which purpose barbed wire appears to be most suitable.

Preliminary trials already conducted at Meridi support the probability that the following species are the most likely to succeed:—

Chloris gayana either in pure stand or in mixture with grasses of recumbent habit such as *Brachiaria decumbens* or *Urochloa Mosambiciensis;*

Botriochloa petusa (not hitherto tried in Meridi but known to be indigenous to Central Equatoria);

Pennisetum purpureum as a possible semi-permanent pasture if initially laid down with an ephemeral species to exclude weak grasses in the early years.

It is suggested that grazing trials should be conducted on these lines at Meridi, and perhaps elsewhere in the Sudan. Fractional grazing methods using small plots or tethered animals should be avoided in favour of the Uganda system already referred to, which has been evolved after many trials of alternative methods. This requires a group of six paddocks of equal size, not less than one acre each, to be grazed in turn for a period of ten days each, so that the cycle is completed and the first paddock re-entered after two months. If adequate supervision is available the number of animals may be varied to ensure that each paddock is eaten down by the end of its tenth day in use. Alternatively a group of fixed size may be used, e.g. five bullocks per acre of rotational paddock or per six acres of total grazing area, and any grass remaining uneaten slashed by hand periodically. With either method it must be emphasized that, if adequate fencing is essential, the availability of a weigh-bridge by which to record liveweight gains is hardly less so. A more intensive method of rotational grazing which has been used, but which is not recommended, is as follows: six paddocks of only one-third of an acre each are used, and are grazed by two animals for five days. Each paddock is thus re-entered monthly.

It may be questioned whether, when Uganda experience suggests that a truly permanent pasture is not a practical possibility, it is not an uneconomic luxury to seek methods of establishing and managing pastures which will only remain productive for three or four years before requiring renewal. Certainly it is a question that would need careful consideration, but it may well emerge that the most economic way of running a dairy under local conditions is as a component of a mixed farm.

Here the broader issue is touched upon, namely the possibility of replacing the present long bush fallow by a shorter one under grass. At first sight the two questions appear to be independent, but a closer examination reveals that they are connected. It would be unrealistic to deny that at the present level of development in western Equatoria, and in the absence of livestock, such a change in fallow management can only be a very far distant objective; but the question cannot be regarded as purely academic and the immediate improvement in dairy management which might be forthcoming is sufficient to justify the initiation of the larger investigation.

THE SOFTWOOD PLANTATIONS OF THE EAST TRANSVAAL AND SWAZILAND

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Through the courtesy of the Director, Department of Forestry, Pretoria, I was privileged to make a tour in February, 1951, of the softwood plantations of the East Transvaal, visiting the Forest Districts of Barberton, Nelspruit, Sabie, Graskop and Tzaneen, and the Jessievale Plantations. At the invitation of Dr. I. J. Craib, a brief visit was made to the afforestation project of Messrs. Peak Timbers, Ltd., at Pigg's Peak in Swaziland.

At the present time the possibilities of large-scale softwood planting in Tanganyika are being examined closely. Suitable land appears to be available, and it is probable that afforestation will prove to be the most profitable type of development in several areas which may soon be accessible. The achievements of the Department of Forestry and of private afforestation companies in South Africa are therefore worthy of study. Extensive softwood planting is being carried out there in the wetter parts of each of the three main rainfall zones, i.e. the summer rainfall zone of the East Transvaal, the winter rainfall (or Mediterranean) zone of the South and South-western Cape Province, and the all-the-year rainfall zone of the south-eastern coastal areas. Of these, only the summer rainfall zone includes areas with climatic conditions comparable to those of the temperate parts of East Africa, and it was for this reason that my visit was confined to the Eastern Transvaal and Swaziland. In this region the Mediterranean pines have not been very successful, but excellent results have been obtained with species from Mexico and the South-eastern States of America.

The plantations are confined to a belt of country covering the wetter east-facing slopes of the North Drakensberg escarpment. Most of the area receives a fairly high rainfall (40 to 80 inches) but some successful planting has been done in drier conditions, both at high and low elevations. The plantations cover the entire altitudinal range of the escarpment from below 3,000 ft. to over 6,000 ft. Most of the planting is done in short grassland where the rainfall is from 50 to 80 inches a year, and the altitude from 4,500 to 6,000 ft. These conditions are considered ideal, and are sought for by private planting companies, but the Department of Forestry is sometimes obliged to plant in less favourable conditions down to altitudes as low as 3,000 ft., with a rainfall of about 40 inches as the absolute minimum. At the highest levels, approaching 6,000 ft., the minimum rainfall required is about 35 inches. In Tanganyika it is probably necessary to go at least 1,000 ft. higher to obtain comparable conditions. Because the Department of Forestry has not been able to obtain sufficient land on better sites, it is in places afforesting long grass areas and even low secondary scrub, though the cost of planting in dense vegetation is so much greater than in short grass high veld that the work is considered doubtfully economic. Local conditions of labour and land tenure make it impossible to use cultivators for scrub clearance, and the squatter method of afforestation, so typical of East African softwood planting, is not used at all.

The geology of the region is complicated. Four main series are recognized, namely: (1) the Pretoria series of quartzitic sandstones and shales, occurring above 5,000 ft. and giving rise to rather infertile soils, which tend to be shallow; (2) the Dolomitic series, underlying the above, composed mainly of calcareous rocks and residual cherts, and occurring between 3,500 and 5,000 ft.: its soils are often fertile but, unless the strata are dipping and fragmented, rooting depth is inclined to be limited; (3) the Black Reef Sandstone, a band of quartzitic sandstone and conglomerate of variable thickness, containing gold-bearing ores, underlying the Dolomitic strata; and (4) the old granite, underlying the whole of the Transvaal system and giving rise to deep granite loams in the foothill areas. Intrusions of dolerite are common throughout and give rise to localized areas of very fertile soil.

The soils derived from all these geological formations are very acid (pH 5 to pH 6) but most of them have considerable effective rooting depth. They are ideal soils for growing pine trees, but not for agriculture. Topography varies from gently undulating to very steep but, because planting is mostly by hand, steepness is no real disadvantage provided that it is

possible to build an adequate network of roads. Most of the parent rocks are deeply weathered and road making is relatively easy.

Most of the plantable land consists of grassland, with limited areas of scrub or remnant forest. It is possible to recognize three main grassland zones, as described below:—

Highland Sourveld, (e.g., Jessievale).—A short grass type with *Themeda triandra* (dominant), *Trachypogon plumosus, Elionurus argenteus, Monocymbium ceresiiforme, Tristachya hispida, Eragrostis chloromelas* and *E. chalcantha.*

Warmer Sourveld (Middle Veld), with taller grasses including *Themeda triandra* (taller form), *Cymbopogon marginatus, Hyparrhenia hirta* (and spp.) and *Trachypogon plumosus.* This is the main type available for afforestation.

Low Veld (Bush Veld).—A tall grass type, usually with low trees, resembling a typical East African "high grass low tree savannah". *Hyparrhenia* spp. (including *H. dissoluta*) are dominant. The trees include several East African species such as *Pterocarpus angolensis, Terminalia sericea, Parinari mobola, Combretum* spp., *Trichilia emetica, Albizzia versicolor, Sclerocarya caffra, Dichrostachys* sp. and *Diospyros mespiliformis.* This type indicates conditions too dry for economic afforestation, but at Salique in Graskop District there is an interesting arboretum, where *Pinus caribæa* and *P. longifolia* have survived and where *P. michoacana* has grown surprisingly well (attaining a height of 40 ft. in 16 years), despite under-thinning.

Various communities of bracken and secondary scrub are being cleared for planting, particularly in the foothills of Graskop District. These scrub associations contain species such as *Syzygium cordatum, S. guineense, Adina galpinii, Rauvolfia natalensis, Anthocleista zambesiaca, Trema guineense, Bridelia micrantha, Mæsa lanceolata, Lachnopylis floribunda, Parinari mobola, Cussonia* spp., *Brachylæna discolor, Gymnosporia* spp., *Rapanea melanophlæos, Apodytes dimidiata* and occasional *Podocarpus* sp. They closely resemble much of the temperate rain forest scrub of Tanganyika.

At one locality in Tzaneen District, planting is being done in high altitude scrub, 3–4 ft. tall, dominated by *Hypericum leucoptychodes* and *Compositæ*, and containing *Buddleja salviifolia, Leucosidea sericea, Passerina montana, Euryops* sp. and *Cliffortia* sp. Such scrub associations are not considered very suitable for afforestation and are planted mainly to round off large acreages of grassland or bracken.

As noted above, the average rainfall is usually between 40 and 60 inches a year but the extreme range is from 35 inches to about 80 inches. Most of it falls in summer between December and April, the dry season coinciding with winter. Frosts are not uncommon, especially at high levels and along cold air drainage lines. They can be a limiting factor in the growth of certain species of eucalypts though damage to pines is rare. Hailstorms are frequent and do a lot of damage.

After many years of trial of a very wide range of species, the pines in common use have been reduced to four, namely *P. patula* Schlecht. and Cham., *P. caribæa* Morelet (form), *P. pseudostrobus* Lindl. and (to a lesser extent) *P. tæda* Linn. The following notes summarize the main characteristics of these species:—

P. patula Schlecht and Cham.—This is easily the most useful and widely planted species in the East Transvaal, growing well at all altitudes from 3,000 ft. to 6,000 ft., and on all soils. It thrives even on shallow "ou-klip", where however it is liable to drought damage. It is very fast growing (second only to *P. radiata*), especially when between five and ten years old. Its branches are rather spreading and smother grass rapidly. It forms a closed canopy in about four years, and regenerates very readily when mature. The timber from immature trees is of the lightest grade and not very suitable for heavy constructional work, but as the trees get older the newly-formed wood at the base of the tree has a higher density and can be used for all the purposes of a softwood [6]. The species is susceptible to damage by fire and hail. After hail damage it is liable to infection by Diplodia disease, *Sphæropsis* (*Diplodea*) *pinea*, but less so than *P. radiata.* When growing in grassland, it is liable to rodent damage until four years old, but appears to be less frequently attacked than *P. caribæa.* It is sensitive to wind damage if under-thinned and then opened up too suddenly.

P. caribæa Morelet.—The form of *P. caribæa* which is now being planted in the East Transvaal is the "Northern" Slash Pine, not the form from South Florida which is

probably the true *P. caribæa.* The original introductions of *P. caribæa* to South Africa came from the entire range of its habitat in North America, including Florida. *P. caribæa* is widely used as an alternative to *P. patula,* especially on dry sites. It is suitable for as wide a range of altitude as *P. patula,* is even more drought resistant, and is therefore especially suited to lower elevations and hotter aspects. It is faster growing than *P. patula* for the first few years, reaching 8–10 ft. in three years. Thereafter it is slightly slower, attaining 50–70 ft. in 20 years. The yield is about 10 per cent less than that of *P. patula.* It grows well in long grass or scrub, but because it has fewer side branches than *P. patula* it takes longer to form a canopy. Although somewhat inclined to forking, and sometimes a little crooked, the *élite* stems left after thinning are usually of very good form. The timber is fairly dense but is not so useful as *P. patula,* owing to a tendency to compression wood. The tree yields a commercial resin in the U.S.A. but is not tapped in South Africa. It is very liable to rodent damage in grassland, and is subject to Armillaria attack on former scrub or forest sites.

P. pseudostrobus Lindl, like *P. patula,* comes from Mexico, and has done almost as well as *P. patula* in many places in the East Transvaal. It is very fast growing and makes good diameter increment, but is not very resistant to frost. The form is usually good, with long, clean internodes, but the bole tends to be rather swollen at the branch whorls. The timber is of good quality but is somewhat marred for constructional purposes by large nodal knots. *P. pseudostrobus* was not planted extensively until recently, partly because its identity was in doubt (it was confused with *P. teocote*) and partly because seed was not available in quantity.

P. tæda Linn. was till recently fairly extensively planted. It appears to be suited to most soils and situations, but on shallow soil or in hot areas is liable to be killed in years of exceptional drought. It is rather variable in form, but is very resistant to hail and although not as fast growing as *P. patula,* it does not lag far behind on good sites. The timber is of medium density; it is inclined to split.

A number of other pines, once in common use, are no longer planted for one reason or another. Even *P. tæda* is not now much in favour, as the timber has proved to be brittle and difficult to work. *P. radiata* D. Don (= *P. insignis* Doug.) is capable of growing extremely well in the Transvaal. Unfortunately, it is very sensitive to damage by hail, after which it usually becomes infected with Diplodia disease. For this reason it is no longer planted in the summer rainfall areas. In Tanganyika, the same liability to infection has been observed in trial plots in wet localities at Mufindi and Old Moshi, but it has grown well near Lushoto and appears to be fairly promising at Ipinda (near Mbeya) in the Southern Highlands. *P. longifolia* Roxb. was formerly planted extensively in the Transvaal, especially in hot, dry localities and on shallow soils, but (although drought resistant and very fire resistant) has generally proved disappointing. Mean annual height increments of up to 3½ ft. have been recorded, the overall average being about 2½ ft. On the best soils it may reach 55 ft. in 20 years. It appears to be unsuited to high altitudes, and has done best on deep granite soils in the foothills (where *P. patula* does even better). The timber is of high density, and in India can be of good quality, but the plantations in South Africa have been found to contain a high proportion of spiral grain which renders many of the trees unsuitable for anything except poles and pulpwood. In India this species yields a commercial resin but it is not tapped in South Africa. *P. canariensis* C. Smith is a Mediterranean species which grows fairly well in the East Transvaal but its rate of growth and girth increment are too low for it to be an economic proposition. It is used mainly in coastal regions on dry sites as a pole crop. It is fire resistant, and regenerates from coppice shoots when felled. The poles are very straight; they bear few side branches but many small epicormic shoots. The timber is of good quality but small dimensions. *P. pinaster* Soland. is another Mediterranean species which prefers the coastal climates in South Africa, but has grown well in a few places in the Transvaal. Its particular merit lies in its resistance to drought and its ability to grow on shallow soils, but most of the strains have a very poor form. The best is the "Portuguese" strain [4] which is fairly straight and about as fast growing as *P. caribæa. P. halepensis* Mill., yet another Mediterranean tree, is not planted extensively in the Transvaal. It is very drought resistant but prefers an alkaline soil. It is showing promise in a few places in Tanganyika. *P. khasya* Royle (= *P. insularis* Endl.), *P. oocarpa* Schiede and *P. leiophylla* Schlecht. and Cham. are fast-growing species which have

been rejected mainly on account of their poor form and if better strains can be selected they may prove useful. The success of various Mexican species has led to a recent study of their taxonomy by an officer who visited Mexico in 1947 [3]. It is very difficult to obtain seed, but small quantities were collected and are being used for trials. The species considered most promising include *P. hondurensis* Loock (a new name for the Honduras variety of *P. caribæa* Morelet), *P. ayacahuite* Ehrenb. and varieties, *P. pseudostrobus* Lindl. (a new high elevation strain of which several hundred pounds of seed were obtained), *P. montezumæ* Lambert (resembling *P. pseudostrobus* but more coarsely branched), *P. michoacana* Martinez (for very dry sites), *P. teocote* Schlecht. and Cham. and *P. pringlei* Shaw.

Nursery Technique

No planting is done in the Transvaal with bare-rooted stock, because the risk is too great: the result is likely to be either complete success or complete failure, according to the weather. Moreover, a lined-out transplant cannot be repeatedly root-pruned and therefore does not form such a mass of superficial fibrous roots as does one raised in a box. Transplants are grown either in wooden boxes or in a bed which can be carved up for transporting in boxes. The latter method is the "Swaziland technique", described later. In order to save boxes and transport, a close spacing of 1½ in. x 1½ in. is universally adopted, which means that a very fertile soil is needed. Seed is usually sown in boxes 10 to 18 months before planting, with no special precautions save that the boxes are sometimes raised on a staging out of reach of pests. Heavy sowing rates are usual and as many as 1,000 seedlings may be lifted from a 10 in. x 8 in. box. *P. patula* however is rather liable to damp off, and not more than about 300 seedlings are raised in a box. *P. patula* seed normally produces 15,000–20,000 plants a pound, *P. caribæa* only 3,000–5,000 (germination being spread over a long period), *P. tæda* 5,000–8,000 and *P. pseudostrobus* about 7,000. Sowing is often done just before or just after the wet season, especially in wet areas, to reduce the risk of damping off. Seed boxes are not usually shaded at any time. Seedlings are always transplanted as soon as the first lateral roots have formed, by which time they are about 1 in. to 1½ in. high. If the root is long, it is chopped off cleanly to about 2 in. length. Transplanting is done under shade (except in Swaziland where no shade is ever used) and the boxes are moved back into the open after a week or two. The usual transplant box measures 10 in. by 8 in. by 5 in. deep. It holds 30 transplants at 1½ in. x 1½ in. This size of box is largely a historical accident, deriving from the half petrol tin which was widely used before tins became scarce. It contains about 260 sq. in. of ½ in. timber or 8.67 sq. in. a plant. A 16 in. box contains 576 sq. in. of timber but would hold 100 plants at 1½ in. x 1½ in. or 5.76 sq. in. a plant, which is a saving of one-third in the amount of timber needed for each plant. The boxes are obtained cheaply from Government mills and unless treated with preservative last one or two years only. In some nurseries the shooks are dipped in molten tar (creosote is liable to be toxic); they then last indefinitely unless broken. Boxes are usually filled with sieved forest topsoil. In the East Transvaal, where there are no nutritional difficulties due to lack of mycorrhiza-forming fungi, there is no need to inoculate with soil from old established plantations, but in Swaziland superphosphate is frequently added at the rate of one part in 300.

The nursery technique at Pigg's Peak, Swaziland, is of particular interest. It is a modification of the normal method, designed to reduce the high expenditure on boxes. Each planting unit has its own nursery which produces about 500,000 plants a year (for 700 acres at 9 ft. x 9 ft., plus blank filling). Each nursery is maintained by a full-time gang of four labourers. The plants are raised in beds 100 ft. long by about 3½ ft. wide. The beds are made of imported soil, and are enclosed by concrete bricks, 18 in. long by 5 in. deep and 3 in. wide. The bricks are laid end to end on a levelled terrace of hard earth and the enclosed space is filled up level with soil. The beds, which are not shaded at any time, are used both for seedlings and transplants. The transplants are lined out at a spacing of 1½ in. x 1½ in. and are root-pruned every 2–3 weeks after establishment by drawing a length of thin steel wire underneath the bed like a flexible saw. The first operation is sometimes a little difficult, especially if delayed, but subsequently this pruning is fairly simple. The method could easily be adapted for use in Tanganyika by using baulks of timber to delimit the beds instead of cement blocks. The baulks need be squared only on the lower and inner faces. The ground on which the beds rest must be level and fairly hard, though permitting free

drainage. At the time of planting out, the concrete blocks are removed and the bed is carved up into sections containing 35 plants each (5 rows of 7). These are lifted on a spade and dropped into standard boxes for transport to the planting site. The soil is bound together by a mass of fibrous roots, and the sections can be dropped into a box without disturbing the plants. It is not necessary to remove one side of the box. The great advantage of this technique is the tremendous saving in boxes, which are used only for transport: they are emptied and returned to the nursery for more seedlings, and in this way may be used up to ten times in a season. About 3,000 boxes are needed for a plant of 700 acres, which is a saving of about 80 per cent. Because the boxes are used only for a short period, they last for several years without preservative treatment. A drawback to the method is that it is not possible to dump large quantities of plants in the plantation area to await favourable planting weather, and it is therefore not so easy to compress the planting into the brief periods when conditions are ideal. It is necessary to have all-weather communications between the nursery and the planting areas: at Pigg's Peak each nursery has a five-ton lorry, whilst ox carts are used for transport from road sides to all parts of the plantation. Considerable care is taken in selecting the soil used in the beds. Basically, it is a 50/50 mixture of sifted grassland topsoil and forest scrub soil. One part of kraal manure is applied to 24 parts of this mixture, and 2–3 lb. of complete inorganic fertilizer (N.P.K.) are added to each 100 ft. of bed. A ½ in. layer of mycorrhizal soil from old pine plantations, i.e. about 10 per cent by volume, is laid as a middle layer in a sandwich of ordinary soil. It has been found that in this area *P. patula* will not grow well unless the soil is liberally infected with mycorrhiza-forming fungi; *P. caribæa* is less difficult. In Tanganyika, heavy inoculation is essential in most areas where pines are planted. The cost of nursery work for a large annual acreage is about Sh. 15 an acre.

Planting Technique

The method of planting is extremely simple. In short grass areas the espacement is marked with a planting chain and the planting pits are dug, in one operation. A small circle is cleared for each plant, and the earth loosened to the depth of a mattock. The grass is usually burned off shortly before planting; this reduces root competition during the first season, but in mature veld may increase it later. Planting can be done during wet weather at any time between December and March. In a few localities, such as Jessievale, where the rainfall is rather low (35 in.) and the slopes gentle, the veld is ox ploughed before planting. The usual sequence of operations is, however:—

April to October.—Dig pits at 9 ft. x 9 ft. spacing (about 5–6 man-days an acre).

November Onwards.—Burn off grass a little ahead of planting.

December to March.—Plant (1 man-day an acre).

Second year.—Weed around each tree (3 man-days an acre). One weeding is sufficient for establishment.

The above schedule applies only to the most favourable high rainfall, low grass areas. In long grass or scrub, costs are much higher, averaging about 40–50 man-days an acre, employed as follows:—

	man-days an acre
Slashing	12
Burning or piling in rows ..	2
Pitting	8
Planting (including transport)	2
Cleanings (4 or 5) each ..	3–5
Blank-filling (about 10%) ..	3–5

The cost of labour is about Sh. 5 a man-day, falling to about Sh. 3 in the remoter areas adjoining native reserve. On this basis, the field costs (excluding supervision and overheads but including nursery) amount to about £3 10s. an acre in the best areas, rising to about £8 an acre in the worst areas. Overheads are very much more than this, and not easy to estimate. European supervision usually consists of a Forester (or Foreman) and a Driver, to every 500–1,000 acres of annual plant, with one qualified Forest Officer to every 5–10 Foresters. Other major overheads are road building and fire protection.

Espacement, Thinning and Pruning

An initial espacement of 9 ft. by 9 ft. (540 plants an acre) is now usual throughout South Africa for all species on all sites. This rather wide espacement is due to the thinning principles enunciated by Craib [1], [2]. It is considered to give the best compromise between permitting free growth until the first thinning and providing an adequate number of stems for the selection of *élite* trees to form the final crop. The espacement of 12 ft. by 12 ft. formerly recommended for poor sites is not now used as it delays weed suppression and offers too meagre a choice of stems when thinning.

In some plantations thinning had to be neglected during the war, but the approved schedules are now substantially in agreement with Craib's recommendations, which advocate much heavier and earlier thinning particularly on poor sites than was the custom previously. Heavy thinning results in an appreciable loss of total volume increment but increases the volume of merchantable timber (defined as logs over 6 ft. long and over 5 in. diameter under bark at the thin end). A summary of the usual thinning schedule for *P. patula* and *P. radiata* is given in the Table below: in the case of other fast-growing species, thinnings are delayed by one year:—

Age	Quality I		Quality II		Quality III	
	No.	Height	No.	Height	No.	Height
		feet		*feet*		*feet*
0	540	0	540	0	540	0
6	540	—	300	22	300	14
8	300	46	300	—	300	—
12	200	64	300	—	300	—
14	200	—	200	55	150	39
18	130	84	200	—	150	—
20	130	—	200	—	100	53
25	130	—	100	79	100	—
30	0	105	100	—	100	—
40	—	—	0	95	100	—
750	—	—	—	—	0	74

In accordance with Craib's principles, initial thinnings are done earlier on poorer sites than on good sites, to reduce competition to the lowest possible level. It is considered uneconomic to grow timber slowly, hence the trees are never allowed to compete severely with each other. The schedule is not, however, applied strictly; it may be modified according to local conditions, or to fit management plans and convenience.

For the slow-growing pines such as *P. longifolia, P. canariensis* and *P. palustris,* the following thinning schedule is adopted:—

Age	No. of Stems		
	Quality I	Quality II	Quality III
0	540	540	540
7	540	540	260–280
8	540	260–280	260–280
9	260–280	260–280	260–280
13	260–280	180–200	130–140
14	180–200	180–200	130–140
18	180–200	100–110	130–140
20	100–110	100–110	70–80
40	0	100–110	70–80
50	–	0	70–80
60	–	–	0

The accepted pruning schedule for all species on all sites is now as follows:—

When mean height is 20 ft., prune to 8 ft. (all trees).

When mean height is 30 ft., prune to 15 ft. (all trees).

When mean height is 40 ft., prune to 22 ft. (150 trees only).

All trees, except those obviously suppressed or crooked, are pruned at the first and second operations because pruning of the selected stems only puts the latter at a disadvantage in competition with the unpruned. If trees are very branchy, as for example with *P. montezumæ,* the local officer may prune at his discretion to 4–5 ft. before the mean height is 20 ft.

Fire Protection and Road Making

The present fire protection policy aims at subdividing the plantations into units of 100–200 acres. Only exceptionally is it possible to use natural features, of which the most useful are ravines filled with dense indigenous forest or scrub. Grass-filled ravines, even those with running streams, are useless, because they contain much inflammable matter and act as wind chimneys. Mostly the subdivision is artificial, usually taking the form of belts of eucalypts, 1–3 chains wide. These are sited where possible on ridges and spurs. The eucalypts grow much taller than the pines and help to arrest sparks. The outside row of pines is sometimes left unpruned to provide a solid wall to reduce wind velocity and stop sparks. Rows of cypress or *Cyncarpia laurifolia* are sometimes used for the same purpose but tend to be suppressed by the pines. All firebelts are cleaned annually by scuffling or raking. This work is often done by women, who are paid a lower wage than men, but even so it costs nearly £2 an acre to hoe firebelts in grassland, and at least Sh. 5 an acre to clean the eucalypt belts. The cost of all measures chargeable to fire protection works out at from Sh. 2/6d. to Sh. 4 a year for every acre of plantation. Fire protection is thus a major item of expenditure. So far, although fires have been fairly numerous they have always been brought under control without extensive damage. However, there is always the fear that the combination of an exceptionally strong west wind with abnormally dry conditions may cause an uncontrollable fire. If this did occur, the East Transvaal plantations would be very vulnerable, as there is now an almost continuous block of forest extending for about 60 miles in the Graskop, Sabie, and Nelsrivier areas, in which most of the gaps between the

departmental plantations have been filled by extensive private planting. The total area involved must be well in excess of 100,000 acres.

The species most commonly planted as firebelts are *Eucalyptus saligna* and (on drier sites) *E. paniculata.* Formerly, a wide range of species was used, including *E. maideni, E. maculata, E. fastigiata, E. amplifolia, E. nitens, E. dalrympleana* and *E. goniocalyx,* but most of these are slower growing than *E. saligna* and more susceptible to insect damage and disease. As it is necessary to keep 10 per cent or more of the area under permanent firebelts, the total acreage of eucalypts is very large. This produce is difficult to sell at present but an increasing market is being developed for *Eucalyptus* timber as well as for poles. The wood, if properly handled, can be used for furniture, floor blocks, etc. [5], and some companies are pruning *E. saligna* in order to produce timber on a Coppice-with-Standards system.

Not included in the cost of fire protection is the considerable expenditure on roads, which are an important aid in controlling fires, though constructed primarily for access and extraction. On an average, about 1 mile of road is needed for every 100 acres of plantation, they are estimated to cost about £150 a mile, but in rocky or very hilly country may cost much more.

When extending new plantations, great importance is attached to laying out all road alignments before the young trees have grown up, even though some of the roads will not actually be constructed until the first thinnings are extracted. At Pigg's Peak most of the road work is done by a D7 Caterpillar tractor and bulldozer which has been completing about 30–40 miles a year, though it can cut a mile in a few days when working in easy conditions. Sheet rock or boulders are sometimes encountered and have to be blasted. About 130 miles have been finished at a cost of about £100 a mile. A small gang of men is employed on building culverts and bridges and maintenance is largely by mechanical graders and an autopatrol.

Yields

Most of the East Transvaal plantations date from the early thirties and have not yet reached maturity but clear-felling has been begun in 20-year-old stands to lengthen the series of age classes for the second rotation. These stands are in general the poorest, and the yields from them are much less than those expected from good plantations at maturity. At Berlin, in Barberton District, *P. patula* clear-felled at 25 years has yielded about 3,500 Hoppus ft. an acre of timber over 5 in. diameter, having already given 2,000 H. ft. of thinnings and 500 H. ft. of smallwood. The height is 85 ft., which makes it marginally first quality.

According to Craib [1], the yields which should be obtainable from *P. patula* are approximately as follows (yield figures in H. ft. an acre):—

Quality	Age	Height	Final Yield	Thinnings	Total Yield
	yrs.	*feet*			
1	30	105	9,100	3,100	12,200
11	40	99	8,000	2,200	10,200
111	50	77	3,600	1,000	4,600

These figures are derived to some extent from extrapolated curves and refer to fully stocked stands ideally treated. In the East Transvaal most of the plantations would on this basis be rated as Quality II, but it appears doubtful whether existing stands will in fact realize the full anticipated yields.

Rodent Damage

Many young plantations have been attacked by rodents (Swamp Rats and Striped Mice of the genera *Otomys* and *Rhabdomys*), which ring-bark the trees near ground level. The total extent of the damage is not great at the moment but the potential danger is immense. The Transvaal Conservancy contains about 26,000 acres of pine trees 1–3 years old, in which a sudden plague of rodents would cause enormous destruction. A recent 5 per cent assessment of the damage over 26,688 acres showed that, out of 702,066 stems examined, 5.3 per cent were dead or dying as a result of rodent damage, with a further 6.9 per cent slightly attacked. The damage occurred mainly in the long grass middle veld areas of Sabie District, where, on about 10,000 acres, 17 per cent of the trees were dead or dying and 22 per cent slightly damaged. The trees are attacked mainly in winter, when they are from 2–3 years old; at 4 years old they become almost immune. In the first year the plants have the benefit of the preplanting burn, which leaves insufficient cover for the rodents. *P. caribæa* is the species most severely attacked but *P. patula* may be killed also. The rodents have many natural enemies, including shrews, snakes, owls and buzzards, and these appear to be sufficient control provided that grass is removed. The most effective control is undoubtedly clean weeding for 2–3 years, but this

is very expensive on a large scale although it also accelerates the growth of the trees.

Water Consumption by Plantations

It was mentioned to me several times during my visit that pine plantations had caused the partial drying up of streams as soon as they had formed a closed canopy and were growing vigorously. The effect is most noticeable in the lower rainfall areas, and is believed to get less when the trees are mature. Greater desiccation is caused by eucalypts grown on a short rotation, but there is no doubt that fast growing pines have a similar effect. The Department of Forestry now makes it a rule not to plant trees within 2 chains of a watercourse.

Organization of Large-scale Afforestation

As an example of the way in which large-scale afforestation is organized by private companies, the following account of the Pigg's Peak project may be of interest as indicating the type of development which might be undertaken in the wetter mountain grasslands of Tanganyika. Peak Timbers, Ltd., is a private afforestation company engaged in the large-scale planting of pines. It has purchased an area of about 78,000 acres (55,000 acres plantable) at an average cost of about £3 per plantable acre, including compensation to a small number of natives. The area is typical mountain grassland or middle veld, with limited areas of very thin scrub. The topography is fairly broken, with elevations averaging about 3,500 ft. but ranging from 2,800 ft. to 5,000 ft. The soils are derived exclusively from deeply weathered granite. Rainfall averages about 47 in. a year. The organization is based upon working units each under the supervision of a European Foreman, four or five such units making up each of the four Forester charges. Each Foreman is in charge of a gang of about 50 labourers, who plant about 700 acres a year. Five Europeans are employed in the Head Office at Pretoria, whilst the local headquarters organization at Pigg's Peak consists of a European Clerk, a Surveyor, a Building Section (1 European in charge of 4 European staff, 8 African skilled tradesmen and 50 labourers) and a Transport Section (1 European in charge of 3 European mechanics, 3 skilled African operators, 3 African mechanics and about 17 labourers). The Transport Section is concerned with the maintenance of field staff vehicles (1 light vehicle and a 5-ton truck to each unit) and with road making.

The first planting block of 35,000 acres has been mapped from aerial surveys made by a private firm. About 120 points were marked for ground control. The cost was about Sh. 1 an acre for the complete survey, including the preparation of a 50 ft. contour map.

Work has been in progress for three seasons, with planting continuing at the rate of about 10,000 acres a year. It is planned to plant the whole plantable area in five years, because it is obviously to the interest of the company to put the whole acreage to productive use in the shortest possible time. The company expects to be able to begin exploitation on a commercial scale within six years (by operating a box-shook plant on five-year-old thinnings) and to start large-scale exploitation in the eleventh year. It will be possible to regulate output by cutting up to the mean annual increment of the crop. It is estimated that the total cost of the plantations, including purchase, overheads, ancillary works, capital charges and protection, will work out at about £25 an acre up to the eleventh year, by which time substantial returns should be forthcoming.

Acknowledgments

It is a pleasure to acknowledge my indebtedness to the Director of the Department of Forestry for making my visit possible, and to many members of his Department for their kindness and hospitality. I wish to record also my grateful thanks to Messrs. Peak Timbers, Ltd., for their hospitality and for permission to publish details of their work. In particular I must thank Dr. I. J. Craib both for his kindness and for stimulating interest in the prospects of softwood planting in East Africa.

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Fig. 1.—Swaziland Nursery, Pigg's Peak. Beds on the left filled with transplants; those on the right under construction.

Fig. 2.—Bergvliet Plantation, Sabie District. Elevation 2,400–4,000 ft.; rainfall 44 in.; granitic soils. View from fire-lookout showing pine plantations broken up by indigenous forest and taller Eucalyptus belts.

Fig. 3.—Brooklands Plantation, Sabie District. Elevation 4,800–5,000 ft.; rainfall 50 in. Pinus caribæa 2½ years old, with fire belts of Eucalyptus saligna

Fig. 4.—Broederstroom Plantation, Tzaneen District. Elevation 5,500 ft.; rainfall 75–100 in., granitic soil. Kloof forest serving as fire-break. P. caribæa, 4 years old, beyond, much thinned by rodents. P. patula on hills behind hardly affected; bare patches due to sheet rock.

Fig. 5.—Ceylon Plantation, Sabie District. Elevation about 5,000 ft.; rainfall 50 in.; shallow shale soil on steep slope. P. longifolia, 16 years old, so poorly grown that all except the best stems removed and P. patula interplanted. The latter (shining, drooping foliage) only 4 years old but already catching up.

Fig. 6.—Salique Plantation, Graskop District. Elevation about 3,000 ft.; rainfall 45–50 in.; deep granitic soils. Dense foothill scrub, with P. caribæa, 2 years old, coming through. P. caribæa and Eucalyptus saligna, 3 years old, beyond road.

Fig. 7.—Spiral Grain in P. longifolia, aged 20 years, height 55 ft., at Bultfontein, Nelspruit District.

Fig. 8.—Natural regeneration of P. patula, 4–5 years after clear-felling, at Berlin, Barberton District.

Fig. 9.—London Plantation. Graskop. General view of private plantation showing type of country afforested. P. patula recently felled; slash piled to aid natural regeneration. Hills across valley all planted.

Fig. 10.—Nelsrivier Plantation, Nelspruit District. Elevation about 3,500 ft.; rainfall 40–45 in. P. longifolia in foreground, 5 years old and about 5 ft. high. P. palustris across valley also 5 years old, but 6 to 10 ft. high.

THE ABIDJAN FOREST CONFERENCE—DECEMBER, 1951

A forest conference for countries in Africa south of the Sahara was held at Abidjan on the French Ivory Coast in December, 1951. It was the first forest conference of its kind and was convened by the C.C.T.A. (Commission pour la Co-operation Technique en Afrique Sud du Sahara).

Fifty delegates attended, of whom 11 were British, 28 French, 4 Belgian, 3 Portuguese, 2 Dutch, 1 Brasilian, and in addition there was an observer from F.A.O. These delegates included representatives of the Colonial Office and Forest Research Institutes of Britain, France and Belgium and Holland. From East Africa there were two delegates from Uganda, one from Kenya, and one from E.A.A.F.R.O.: the latter also represented Tanganyika and Zanzibar. The British delegation was led by F. S. Collier, the Forest Adviser to the Colonial Office. The Conference Translator was Mr. Barker, also from London, and he was assisted by Mlle. Bourjois who teaches English at the College in Abidjan.

The Conference was opened by the Governor of the Cote d'Ivoire and was closed by the Governor General of French West Africa. It was comprised of two sections, one of which dealt with forest policy and education and the other with silviculture.

The Conference not only sat round a table and talked in many languages, but many opportunities were taken to see the forests of the Ivory Coast and its forest industries. One short tour to the north of the territory was also undertaken. The conference was a great success, for not only were sound recommendations made, but it helped to break down the rather parochial outlook of many African territories. We all got to know our opposite numbers and what they were doing about problems similar to ours.

In addition, we saw many things of interest to East Africa. Near Abidjan we visited a paper mill which is entirely using local tropical woods and is utilizing 100 per cent of such produce. This is probably unique in Africa, and a similar plant would greatly help us here in our utilization of what is at present waste. At Yaounde in the French Cameroons there is a wood distillation plant, also probably unique in Africa, which is producing such products as charcoal, coal tar, pyroligneous acids, meta gas, methyl alcohol, acetic acid, acetone, tar, creosote, pyridine, and a wood preservative called "pyrolineum". Such a plant has great possibilities in East Africa, especially in connexion with soft wood schemes.

Some of the resolutions of the conference were very pertinent to East Africa. Extracts from the recommendations are:—

(1) That for each territory a statement of forest policy should be made at the highest administrative level and published.

(2) That all Governments should without delay ensure the creation and protection of an adequate forest estate and that any change in the status and objects of managements of this estate should only be made at the highest administrative level.

(3) That the forest estate should be managed in accordance with the principles of a sustained annual yield.

(4) That forest works for which long period planning is necessary should be financed either by special funds or by funds over a period of years.

To discuss these recommendations as they apply to East Africa, not all the territories yet have written a published forest policy. No territory yet has an adequate forest estate, though Uganda is rapidly attaining one.

All territories are dependent on annual vote and hence long-term forest planning is greatly hampered. Finally, in East Africa there are as yet very few forest working plans which alone ensure conservative working on the basis of a sustained yield.

Many of the recommendations of the silviculture section, which were largely technical, confirmed decisions already reached at the meeting held in 1950 of the E.A. Specialist Committee on Forest Research.

The conference was thus very useful in drawing our attention to some of our basic forest needs which are so often liable to be forgotten in the pressure of day to day work.

Abidjan also had its lighter moments. It was surprising how the language problem was overcome, and on one occasion everyone understood what was going on except the interpreter, but this was due to his being submerged in technicalities. We even got as far as producing some unofficial minutes, which are reproduced below.

Unofficial Minutes

Sur le pont d'Abidjan
On attend la Conférence
On discute (some are mute)
De politique et de finance.

Young and old, small and great
Stand in need de l'interprète;
Toutes les choses forestiere
Sont traduisées par *Barkere.*

Monsieur X . . . . holds the floor
O mon Dieu! je (presque) dors
If this happens every day
Moi, je serai épuisé.

Day by day les delegués
Find a deal too much to say
Ou la forêt et ses lois
Angliséd par *La Bourjois.*

Feux de brousse—what's the use?—
Always lead to much abuse:
Questions such as this must be
Subject to psychologie.

Lead the way dear *Collier*
Pour les gens de la U.K.
Tip le Président the wink
J'ai de soif, I need a drink.

A.L.G.

THE FOREST DEDICATION SCHEME OF THE BUGANDA PROVINCE OF UGANDA

One of the great difficulties of the East African territories is the creation of an adequate and legally secure forest estate. The area of Forest Reserve is pitifully small, and at present totally inadequate. Coupled with this is the destruction of private forest, but good news has come in the start of the Forest Dedication Scheme of the Buganda Province of Uganda. The inauguration of this scheme is ably written up by Mr. R. G. Sangster of the Colonial Forest Service, in two leaflets, one describing the scheme in general, and the other the working plan for the first dedication of indigenous forest*.

The origin of the scheme is described by Mr. Sangster as follows: "Few, if any, landowners have hitherto appreciated the full potential of their forests in terms of permanent timber productivity. Some have regarded them as a reserve of future arable land, and their object has been to sell the large trees as timber and the small trees as firewood, as a preliminary to clearing for cultivation in order to increase their tenantry and their incomes from rents. Others, while not actually destroying their forests, have allowed them to be overexploited to a degree which leaves little more than a tangle of creeper and scrub where once productive timber grew. A few have carefully guarded their forests, but none have actively sought to regenerate them by planting or by tending natural regrowth.

"It was in considering means of preserving and restoring private forests that the Buganda Native Government in 1947 accepted in principle the idea of operating a dedication scheme through its own forest service. Such a scheme was regarded as a social service the benefits of which would be measured not in terms of revenue to the Buganda Government, but in terms of the preservation and proper management of a national asset in the hands of private owners".

The first dedication was in 1950 of some 50 acres of poor savannah which was planted with Eucalyptus for providing poles and firewood. The first dedication of indigenous forest was in 1951 by His Highness the Kabaka of Buganda. During a visit to Britain he was able to study the dedication scheme as adopted there and on his return signed a dedication agreement with the Buganda Government placing 900 acres of his private forest under their management.

For various local reasons the Buganda Government has approached the dedication problem from a different angle from that obtaining in Britain and in Jamaica, in that it has undertaken direct management of private forests. The dedication agreement is a lease voluntarily entered into by the landowners. The period of the lease is fixed considering firstly the time required to complete establishment and tending of regeneration, and secondly the interval necessary for the Buganda Government to recover its financial outlay from the proper working of the area. This may be (say) 12 years for gums and 80 to 90 years for indigenous forest. No annual rent is charged; instead, a premium is paid to the landowner. The Buganda Government waives interest on the capital it invests in the forest. It is to be remembered that the scheme is a demonstration to landowners that properly managed forests are a paying proposition, therefore the Buganda Government is content with making the demonstration and does not seek to make a profit.

Periodical disbursements of profits to the landowner are made during the currency of the lease depending on the state of regeneration and tending. Twenty-five per cent is retained by the Buganda Government in order to hold out a later inducement to the landowner to undertake proper management of the forest once State control is ended. If this has been done for a given period then the balance of profits is handed over.

Such is the general outline of the scheme. It has made a good start and it will have the best wishes of all those who have the protection of East Africa and the rehabilitation of its degraded lands at heart. Uganda should congratulate itself in being one of the few countries of the Commonwealth to have progressed as far as this important stage, that of convincing local landowners that forest land is a national asset to be properly looked after and not to be destroyed, for even if they have the legal right to do so they have no moral right.

The two short leaflets will I am sure be read with the greatest interest by all loyal minded East Africans who have the welfare of the country at heart. A.L.G.

* Sangster, R. G. (1951). The Forest Dedication Scheme in Buganda Province. Govt. Printer, Entebbe.
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BOOK REVIEWS

THE CLASSIFICATION OF WEST AFRICAN LIVESTOCK, by I. L. Mason, Animal Breeding and Genetics Research Organization, Institute of Animal Genetics, Edinburgh. Published by Commonwealth Agricultural Bureaux, Slough, Bucks.

Interest in this publication for the stock-owner and stock improver in East Africa lies largely in the comparisons which may be drawn between the unknown indigenous types of domestic livestock of West Africa with the more familiar native types of East Africa. The limitations to a comparative study of these breeds in West Africa, due to "topographical political and language barriers" is stressed in the introduction and the object of the publication is two-fold, viz. to indicate sources of information for those interested in further study and to establish a framework into which the types can be fitted to reveal the relationships between breeds of neighbouring territories.

Many of the sources of information have been personal opinions, published and unpublished, and the author has accomplished in 34 pages the herculean task of sifting substantiated facts from much conjecture. He has been wise to confine the classification to visual hereditary characters rather than to hypothetical origins.

The publication is intended to be a preliminary written record which can be amended as closer study reveals inaccuracies. The plates are excellent and give with the data on live weights and body measurements a very clear picture for the comparative study of East African native breeds, on which a publication of this nature is overdue before cross-breeding obliterates the genuine indigenous types.

The revival of interest in tropical and sub-tropical countries in the indigenous breeds makes the publication, priced 10s. 6d., a valuable one outside the territorial area of the subject matter and the controversial points regarding local names will not reduce its interest to readers and breeders in East Africa.

W.G.B.

LEAF CURL DISEASE OF COTTON, by S. A. J. Tarr, published by the Commonwealth Mycological Institute, Kew, Surrey, 1951, price 12s. 6d.

This well produced and illustrated booklet gives a full summary of our present knowledge of an important African cotton disease. It will interest East African plant pathologists and others concerned with the cotton plant; for besides providing a useful account of the modern methods of approaching the control of a crop disease, which has general applications, it describes a disease that may well become a factor for consideration in East Africa, even though it has not been recorded here to the present day.

Leaf curl of cotton is known certainly to occur only in Africa and only in Nigeria and the Sudan. Although first reported in 1912 and suspected to be a virus disease in subsequent years, the foundations of knowledge of its nature and manner of spread were laid in 1930-31 through the researches in the Sudan by T. W. Kirkpatrick, whose later work on coffee pests and other problems in East Africa will be remembered.

Leaf curl is a virus disease transmitted by a white fly (*Bemisia* sp.). It is believed not to be transmissible by sap-inoculation, or to be carried over in soil, plant debris, or in the seed. Survival of the virus from one crop to another is in the stumps of perennating cotton plants—or alternative host plants, which are known, but only in the family Malvaceæ.

In the Sudan a satisfactory degree of control was obtained by uprooting all cotton plants at the end of the season, and prohibiting the growing of certain other Malvaceous plants.

But perhaps more striking results have been followed by the use by plant breeders of genetical factors for resistance to leaf-curl in species of the genus *Gossypium*. In general the Sea Island and Egyptian types are susceptible; American types are less susceptible, and Asiatic types are highly resistant. Consequently the plant breeder has ample material on which to call. Even the Egyptian cottons may carry factors for resistance, and work in the Sudan has produced by selection within the Sakel crop types that show outstanding performance in leaf-curl areas.

Mr. Tarr surveys the problem in 23 sections, covering the origin and geographical distribution of leaf-curl, its symptoms, transmission and control, and describing a number of similar, possibly related diseases of cotton and other plants. It is of interest that the leaf-curl virus of tobacco, prevalent in East, West and South Africa, produces similar symptoms and a similar insect-transmitter; but this virus has never been transmitted to cotton, nor the cotton leaf-curl virus to tobacco.

It is to be hoped that the Commonwealth Mycological Institute will continue to produce monographs upon individual diseases similar to the present one.

H.H.S.

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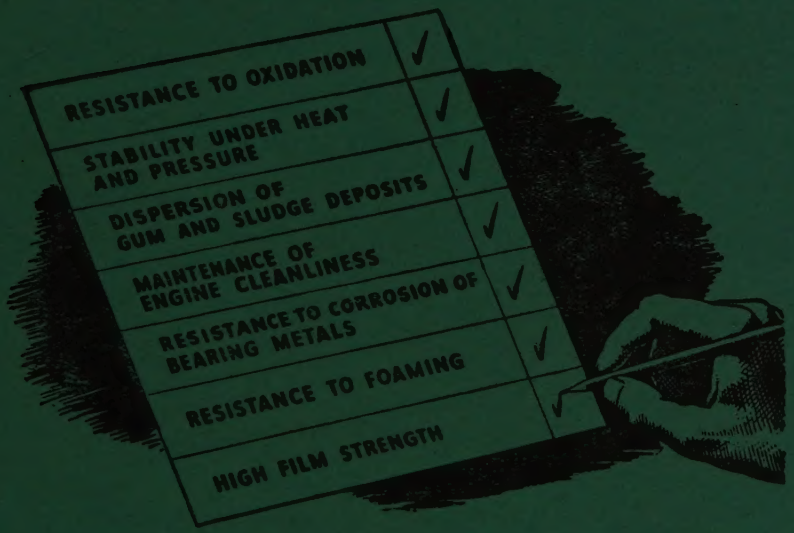

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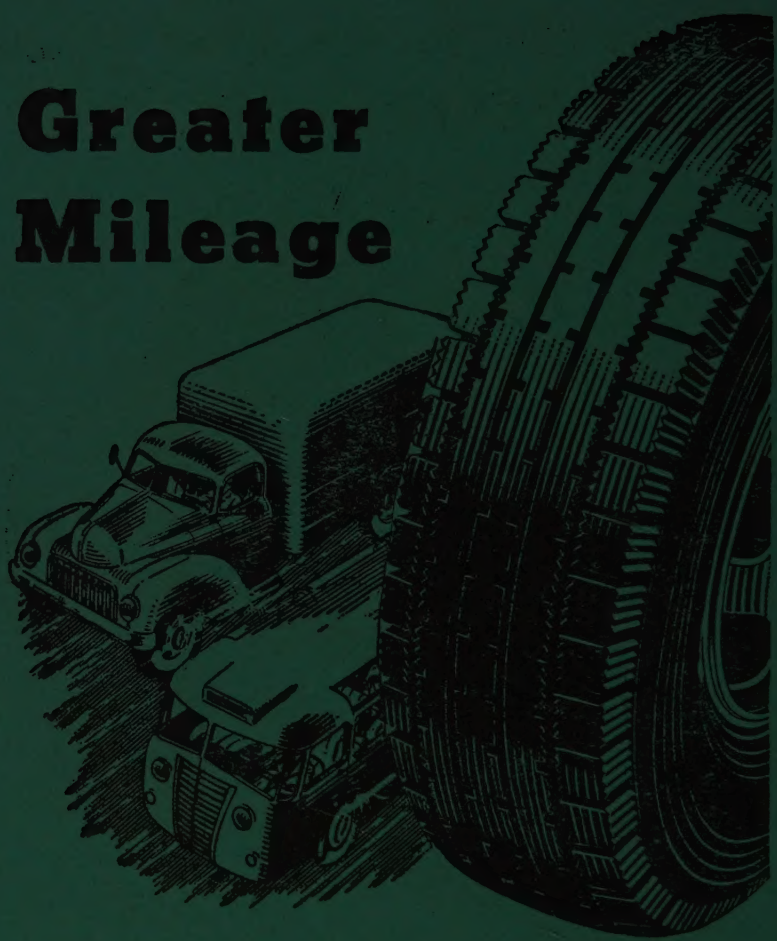

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